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ABSTRACT

This document presents a sample of grades 6-12 science curriculum on Earth resources to promote scientific literacy. This natural resource-based curriculum uses an inquiry-based, hands-on approach and allows for community partnerships during student learning processes. Lessons plans included in this curriculum are divided into 4 categories: (1) Locating, Acquiring, and Processing Our Earth's Resources; (2) Using Our Earth's Resources; (3) Disposing of Our Earth's Resources; and (4) Reducing, Reusing, and Recycling Our Earth's resources. This sampler provides an entire sample lesson from the second category called "Getting Crude Oil: Oil Extraction". (YDS)

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EARTH RESOURCES

A Case Study: Oil

SAMPLER

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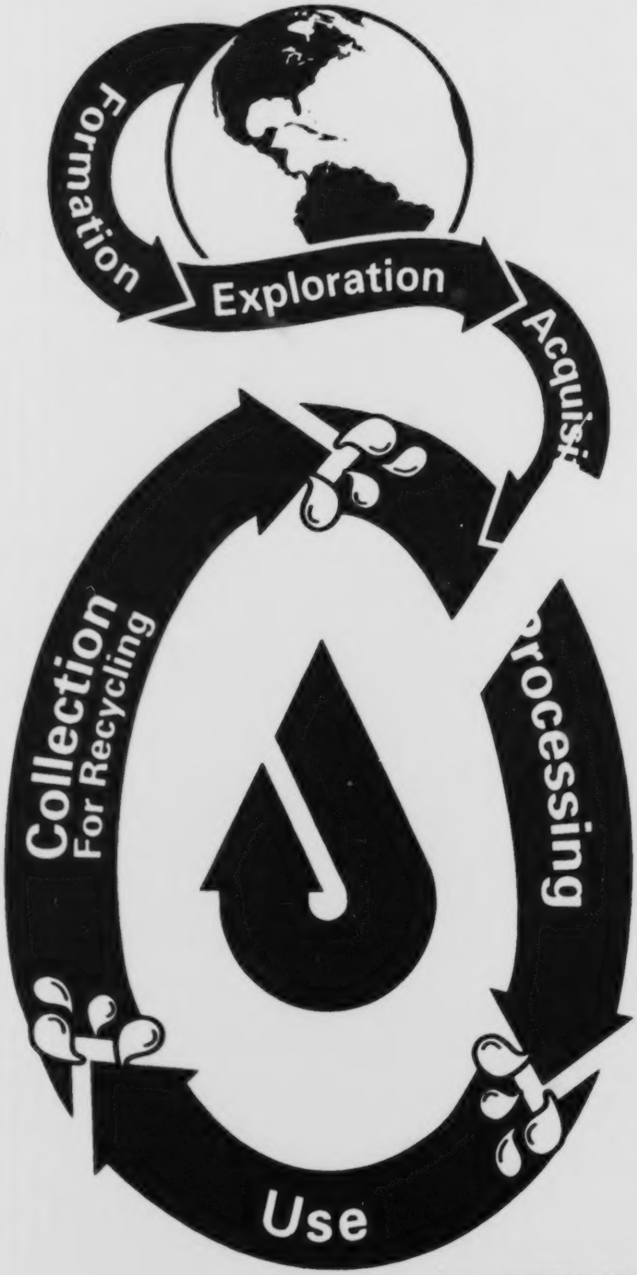

A 6th-12th grade curriculum to promote scientific literacy

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A Letter of Endorsement...

Dear Educator:

Increasingly, schools are facing the challenges of implementing new standards for science education and integrating environmental education into the classroom. *Earth Resources — A Case Study: Oil* is a curriculum that can help educators to meet this challenge. It was developed through a collaboration between the California Scope, Sequence and Coordination Project, the Integrated Waste Management Board, and the California Department of Education.

I am confident that you will find that the *Earth Resources* curriculum makes science more relevant and interesting for your students. Because *Earth Resources* was written to align with the *California Guide to Environmental Literacy, National Science Education Standards, Benchmarks for Science Literacy*, and *California Science Framework*, it is developmentally and conceptually appropriate for 9th and 10th grade students. This curriculum would make an excellent addition to programs in integrated/coordinated science, environmental science, and traditional science.

With its hands-on, inquiry-based approach, *Earth Resources* facilitates learning by allowing students to actively construct their own knowledge of environmental science concepts and issues through research, discussion, exploration, and application. Each lesson fosters conceptual change by enabling students to revisit, analyze, and adjust their preconceptions.

While *Earth Resources* engages students in learning about the importance of natural resource conservation, its greatest strength lies in providing in-depth knowledge about oil formation, exploration, acquisition, processing, and everyday use, as well as enlightening students about the proper disposal and recycling of used oil. Of significance to local communities and recycling programs, this curriculum also provides students with the cognitive skills to develop strategies for responsible action and community outreach.

Sincerely,

Bill Andrews

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Winston H. Hickox
Secretary for
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Gray Davis
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February 2001

Dear Educator:

The Integrated Waste Management Board (CIWMB) is pleased to provide you with an excerpt from our curriculum, *Earth Resources—A Case Study: Oil. Earth Resources* (ER) is a 6th through 12th grade curriculum which features over 18 engaging lessons enabling students to learn about the lifecycle of a natural resouce (using oil as a case study)--how it is formed, discovered, extracted, processed, used, collected, and recycled. Through hands-on laboratory investigations, students identify environment. They will explore the science concepts behind the decisions they will need to make and some of the consequences of these decisions.

This document, which we have coined the "ER Sampler," includes the following excerpts from the complete curriculum: the introduction, the "Section At A Glance" for all four sections; one lesson; and the table of contents for the appendices. The introduction gives you a comprehensive explanation of the how, why, when, who, and what that went into developing this curriculum, plus the curriculum's features and how to use it. The Section At a Glance pages contain a complete synopsis of each section, including lesson summaries and a matrix on lesson concepts, scientific thinking processes, and desired outcomes, plus so much more!

Lesson 4 from Section One is a lesson on "Getting Crude Oil: Oil Extraction." While most of the Earth Resources curriculum is spiraling and builds upon previous learned concepts, this particular lesson is pretty autonomous with very little reference to prior lessons the students have completed. It has a hands-on experiment, which requires the students to build an extraction pump. We think you and your students will find it informative, interesting, and engaging. The last part of the ER Sampler is a one-page overview of the appendix. (Appendix A is included with Lesson 4 in this ER Sampler.) When you review the appendix overview, you will discover there is a wealth of information in the 11 appendices included in the full ER curriculum.

We hope this excerpt will whet your appetite and compel you to sign up for an ER workshop so that you can receive a complimentary copy of the full ER curriculum. To find our about a workshop in your area or to help organize one, please contact the CIWMB regional representative for your area. See the regional map on the next page.

Thank you for your interest in teaching our youth about environmental stewardship through this unique vehicle on the study of oil.

Respectfully yours,

Linda Moulton-Patterson

Linda Moulton-Patterson, Chair
California Integrated Waste Management Board

California Environmental Protection Agency
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The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption.
For a list of simple ways you can reduce demand and cut your energy costs, see our Web site at http://www.ciwmb.ca.gov/.

Office of Integrated Environmental Education

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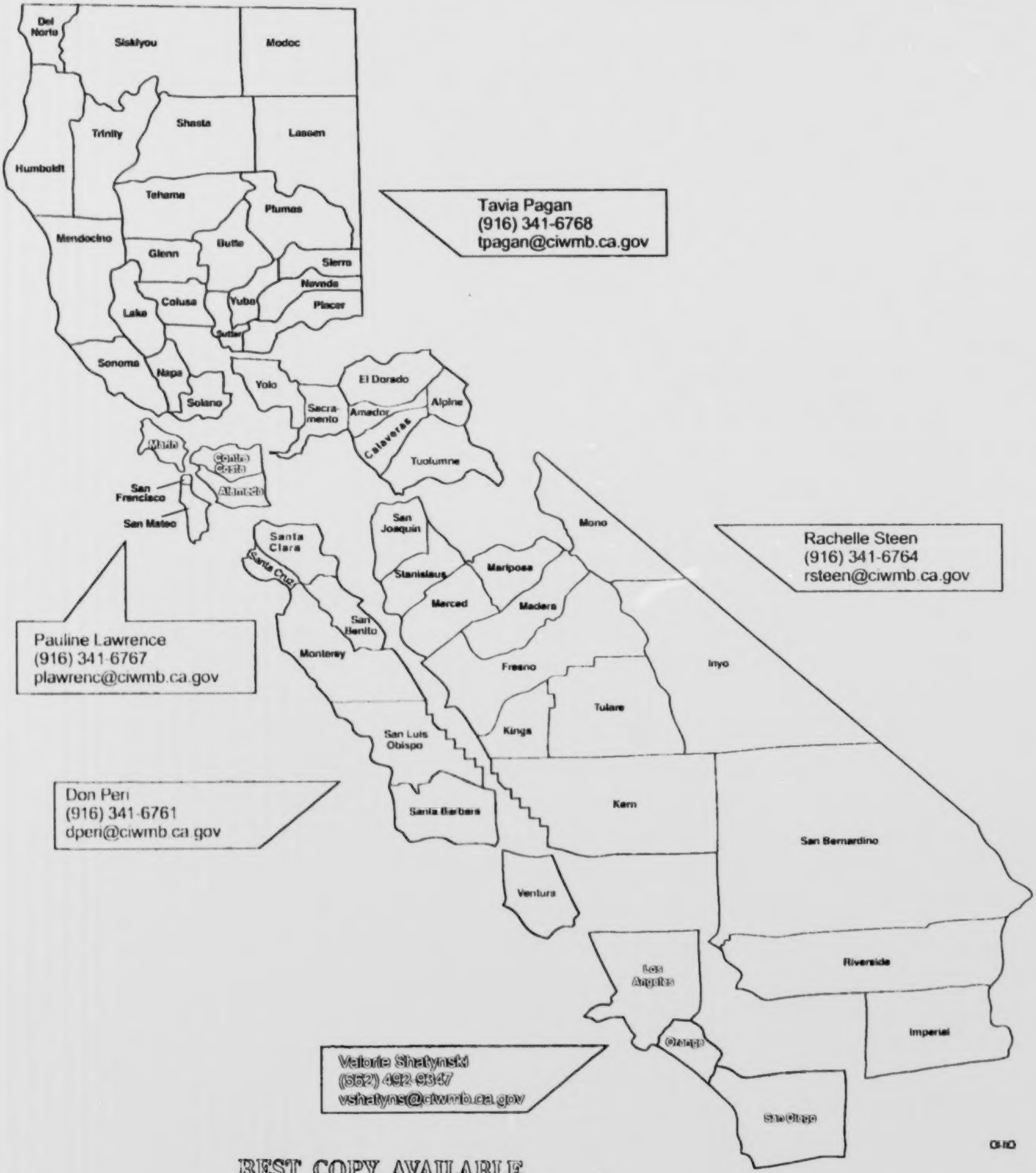
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Meeting California's Environmental Education Challenge

Each year, Californians generate approximately 45 million tons of solid wastes. As our population grows and the number of landfills becomes scarce, the need to manage the ever-growing quantities of waste materials becomes more important. The Integrated Waste Management Board (IWMB), as part of the California Environmental Protection Agency, is responsible for implementing a comprehensive set of laws designed to address California's solid waste disposal needs and lessen the demand upon our natural resources. The IWMB has a public information and educational mandate as part of its overall mission, which includes school programs. In all its outreach activities, the IWMB promotes an integrated waste management hierarchy emphasizing the four Rs: reduce, reuse, recycle, and buy recycled.

Teachers can educate California's youth about the importance of these actions, teaching them waste management skills that will last throughout their lives. State and local agencies can support the education community by providing resources, materials, and motivation to promote waste management concepts. Teachers should look to state and local government programs for information and materials to support their efforts.

In California, as part of its overall solid waste management efforts each city and county must develop programs to safely manage household hazardous wastes (HHW) generated within its jurisdiction. Many jurisdictions maintain local HHW collection networks and support school programs or give classroom presentations as part of their public education efforts. The IWMB operates a program specifically focused on used motor oil recycling. This program offers grants to local jurisdictions to provide used oil collection and conduct public outreach. The IWMB is also charged with the development of an information and education program for used oil recycling as well as the promotion of recycling and source reduction of solid wastes.

In developing both the used motor oil recycling program and the schools program, the IWMB discovered the compelling need for curricula that focused on the responsible use of resources. Local program managers and science teachers sought up-to-date materials that meet the most recent teaching standards and provide environmental, resource conservation, and recycling messages. Such a curriculum, it was hoped, would be built on a coordinated science approach that interlinks life, physical, and Earth sciences while weaving concepts around a central theme that is related directly to students' lives.

A tool to meet this challenge has now been developed. *Earth Resources — A Case Study: Oil* is a natural resource-based curriculum that presents oil as a case study and contains hands-on, inquiry-based lessons. Through the curriculum, students explore the formation, extraction, and processing of crude oil; the use of motor oil and the environmental impact of its improper disposal; and the benefits of recycling used oil. By using this curriculum and partnering with local governments, teachers can also help develop strong connections between their students and communities.

This curriculum was developed in partnership with the California Department of Education and the California Scope, Sequence and Coordination (SS&C) Project, with support from the IWMB. To develop the curriculum, SS&C brought together teams of teachers from across the state who are experienced in designing lessons, embedding assessment, and field-testing materials. An advisory group consisting of educators, scientists, and representatives from environmental organizations and oil and oil recycling industries provided guidance on content.

These partners and contributing experts are confident that *Earth Resources* will equip students with the knowledge and skills to make a difference toward protecting the environment.

Introduction

Earth Resources — A Case Study: Oil is a curriculum designed to promote scientific literacy and to enable students to make responsible decisions. When they are based on scientific knowledge, responsible decisions help to promote the wise consumption of resources. As human consumption of Earth materials increases, it is imperative that students explore the environmental issues associated with the processing, use, disposal, and reuse of resources. The concepts explored in this curriculum focus on the issues associated with motor oil, but can be applied to any Earth material used by humans.

The *Earth Resources* curriculum was developed in a collaboration between the Integrated Waste Management Board, the California Department of Education, and the California Scope, Sequence and Coordination project. All three groups favored targeting high school students due to their interest in automobiles, their high proportion of "do-it-yourself" oil changing, and their growing role as consumers. The project partners agreed that responsible behaviors should be established early, rather than changing entrenched behaviors later through future education.

The curriculum unit is designed for 9th and 10th grade science students. Aligned with the *National Science Education Standards* and the *California Science Framework*, the curriculum enables students to focus on the use and conservation of a natural resource through the case study of motor oil. Its content is divided into four sections. The first section focuses on the formation, exploration, and processing of the resource; the second section explores the use of the resource by consumers; the third section discusses the routes of disposal into the environment and the related impacts; and the fourth discusses opportunities for individual actions. As students explore the issues surrounding the use of motor oil, they are encouraged to apply the concepts to other resources and consumer products such as aluminum, paper, and glass.

The *Earth Resources* curriculum facilitates student learning by utilizing a variety of instructional strategies. The lessons were crafted and field-tested by science teachers throughout California to actively engage all students. As the curriculum unfolds, students employ scientific thinking processes to build their conceptual understanding. The curriculum provides facilitated learning prompts and assessment strategies to accommodate a variety of student learning styles.

The following facilitated instructional strategies are used in the lessons:

- "Hands-on, minds-on" investigations and activities
- Inquiry-based instruction where students are encouraged to explore their previous knowledge and preconceptions, discover new information, scientifically investigate and apply the new information, and compare their findings to their previous knowledge
- An integrated science approach that not only enables students to study Earth, life, and physical sciences, but also allows them to understand the connections between the sciences
- Collaborative study where students are required to work with other students, listen to and value the diverse ideas of other students, and to solve problems after considering all concerns
- A wide range of assessment strategies to enable all learners to demonstrate their conceptual as well as factual understanding of the content

Through these instructional strategies, teachers can guide their students toward the achievement of each lesson's desired outcomes, which are based on the science and issues surrounding the use of Earth resources. In so doing, teachers can help their students to become responsible decision makers and informed members of a global society.

Organization and Features of the Curriculum

Earth Resources — A Case Study: Oil is divided into four sections, as follows:

- Section 1: Locating, Acquiring, and Processing Our Earth's Resources
- Section 2: Using Our Earth's Resources
- Section 3: Disposing of Our Earth's Resources
- Section 4: Reducing, Reusing, and Recycling Our Earth's Resources

Each section supports the unifying concept of the curriculum. All of the unifying, section, and lesson concepts are based on the *National Science Education Standards, Benchmarks for Science Literacy, California Science Framework,* and *California Guide to Environmental Literacy.*

The following chart provides an overall perspective of the concepts addressed by this curriculum.

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interaction of matter and energy.

SECTION 1:

Locating, Acquiring, and Processing Our Earth's Resources

Section Concepts

Human: Natural resources are used by human populations in order to maintain and improve their existence.

Scientific: The Earth's natural resources are formed over time. These resources have observable physical and chemical properties.

SECTION 4:

Reducing, Reusing, and Recycling Our Earth's Resources

Section Concepts

Human: Human activities should aim at maintaining a sustainable system through careful management of the Earth's resources.

Scientific: All matter has observable chemical and physical properties which govern its interactions.

SECTION 2:

Using Our Earth's Resources

Section Concepts

Human: Human use of the Earth's natural resources is based upon chemical and physical properties.

Scientific: All matter has observable chemical and physical properties which govern its interactions.

SECTION 3:

Disposing of Our Earth's Resources

Section Concepts

Human: Materials from human societies affect both physical and chemical cycles of the Earth.

Scientific: Because ecosystems are interdependent, a change in one system may have far-reaching effects on the others.

Adapted from essential documents: *California State Framework, National Standards, California Guide to Environmental Literacy*

SECTION AT A GLANCE

This component of the curriculum provides an overview of each section and its lessons. It is provided to facilitate teacher planning and advance collection of the materials needed to implement the curriculum.

Each *"Section at a Glance"* includes:

- The unit's unifying concept and section concepts.
- An overview statement describing the focus of the section.
- Overview statements describing the activities of each lesson.
- A chart listing each lesson, the corresponding lesson concepts, scientific thinking processes used in each lesson, and the desired student outcomes for each lesson.
- Materials lists and teacher preparation steps for each lesson in the section.
- A storyline designed to actively involve the student in a scenario skit, to be performed by the students in class before the section begins.
- A list of suggested assessment strategies and sample questions and/or prompts that may be used to enable students to demonstrate their conceptual understanding of the section and/or lessons.
- A lesson outline, suggestions, and tools for the ongoing Earth Resources Project — Student Case Study.

THE EARTH RESOURCES PROJECT — STUDENT CASE STUDY

The *National Science Education Standards* emphasize that students should experience science as inquiry which engages them in the active construction of ideas and explanations. Students should be guided to generate questions that make it possible to analyze data, develop a richer knowledge base using science concepts, make connections between evidence and explanations, and recognize alternate explanations. The *Earth Resources* curriculum supports these concepts through the use of an Earth Resources Project — Student Case Study.

This project encourages students to select an Earth material, other than oil, on which to conduct research for their own case study. Using their newly gained knowledge and concepts learned in the oil case study, students apply the patterns of extraction, use, and disposal to their chosen material. Complete details about the project and lesson outlines for student research days are located at the end of each *"Section at a Glance."*

ASSESSMENT OVERVIEW

The assessment component of *Earth Resources* is designed to provide suggestions for evaluating the students' knowledge and growth throughout the curriculum. A variety of suggested assessment methods are outlined within each *"Section at a Glance."* The strategies vary in the complexity of evaluative processes used. Some of the strategies are designed to assess student progress, understanding, and application of lesson concepts, while others are appropriate to assess section or unit concepts.

The goals of the assessment strategies are to evaluate the following:

- Conceptual understanding by individual students
- Students' individual and team skills (i.e., evidence of active participation in questioning, sharing, and discussing; and skills in investigating, data-collecting, and collaborating)
- Habits of the mind (i.e., students' ability to show diverse thinking, be curious, demonstrate critical thinking, respect different points of view, and demonstrate the capacity to change their minds when appropriate)

For more information about the assessments developed for this curriculum, see *"Assessment Strategies"* (page 22).

THE STUDENT SERVICE–LEARNING PROJECT

What is the purpose of an educational endeavor, if nothing is done with it afterwards?

An important goal of this curriculum is to encourage student participation in public outreach programs that support used oil and filter recycling programs in every community. When students use the science learned in this curriculum to substantiate community action, they will serve as convincing advocates. The best way to do this is to actively involve students in the community through a service–learning project.

After students have completed the *Earth Resources* curriculum, they will be asked to design and implement a service–learning project. The details for the project are located at the end of Section 4. In addition, more information and some assessment strategies for service learning projects are discussed on page 30.

CAREER CONNECTIONS

In developing the *Earth Resources* curriculum, one of the goals is for students to experience some of the excitement and challenges felt by those in environmental science and petroleum industry-related careers. Because *Earth Resources* uses pedagogical methods that make science content and issues relevant to students' own lives, it is designed to heighten students' enjoyment of science, enable them to experience success in science, and encourage them to consider science-related careers.

In an effort to connect integrated science content with careers, the appendix of the curriculum provides activity ideas for students to investigate a variety of careers related to the lessons. In addition, the curriculum's appendix features a list of contact information for organizations, publications, and web sites that can provide resources about related careers, workplace procedures, and the science and mathematics behind them.

Description of Lesson Components

In each lesson of *Earth Resources — A Case Study: Oil,* the following components appear in the order indicated.

SECTION #:

Section Title

Section Concepts

Human: Each human concept is based on the *National Standards for Science Education* and the *California Science Framework*; it addresses human impact on the ecosystem.

Scientific: Each scientific concept is based on the *National Standards for Science Education* and the *California Science Framework*; it addresses the scientific content of each section.

LESSON CONCEPT

The lesson concept is the specific concept taught by the lesson. The concept might be either more science-related, more human-related, or a combination of both.

LESSON OVERVIEW

The lesson overview briefly explains the lesson and the student action involved in the lesson.

DESIRED OUTCOMES

The desired outcomes indicate the expected student learning after students have performed the activity. The outcomes are developed in two statements: the first is a general statement pertaining to resources, and the second statement is specific to oil. The desired outcomes are related to the *California Science Framework.*

Students will use the following scientific thinking processes:

> This process-oriented section lists the scientific thinking processes used by the students during the lesson.

STEPS FOR TEACHING

Teacher Action	Student Action	Suggested Time
This lesson component maps out the steps and actions of the teacher necessary to facilitate the desired student outcomes.	This component outlines the activities of the students toward gaining an understanding of the lesson concepts.	This component lists the estimated times for each part of the lesson. Professional judgment of student capabilities should be used in determining the actual times needed.

BACKGROUND FOR TEACHERS

This lesson component provides teachers with some relevant information needed to facilitate the lesson. It is assumed that the teacher has a general knowledge of the scientific concepts being used in the activity. However, new information is provided to help infuse scientific concepts into the specific content of the lesson.

References used to construct the lesson or background information and recommendations for further investigation are cited as needed.

GETTING READY

This component lists the teacher's steps for advance preparation that are necessary to facilitate the lesson.

TEACHER NOTES

This component may be provided to offer additional tips to facilitate the lesson.

KEY WORDS

This lesson component lists the terms and definitions which are essential to the lesson. As they are discussing the concepts, students may not use the correct term, but may instead use "transitional language" to facilitate their understanding. Teacher are advised to attach scientific vocabulary to this "transitional language."

WHAT YOU WILL NEED

This component provides a list of materials and equipment needed to perform the activity. This section is designed in two parts: the first lists the materials and equipment needed for the entire class; the second does so for each group of students.

ACTION NARRATIVE

The action narrative is a possible script of questions that can be used by the teacher to facilitate student learning. Teacher script is indicated in bold print. Some typical student responses are provided in non-bold print.

Prethink

__ minutes

This lesson component sets the stage for the lesson. A connection to past lessons is provided as well as an opportunity for students to identify previous knowledge about the lesson, an essential aspect of inquiry-based learning. An important part of the Prethink is for students to record their preconceptions so that they can be re-examined at a later point in the lesson. An estimate of the time needed for the activity is provided.

Problem for Student Investigation

This component sets the stage for the student investigation. The Problem for Student Investigation is then used to engage the students in the activity by directing them to construct a prediction/hypothesis for the activity.

Student Action

__ minutes

This component introduces the student investigation, with notes on safety as needed. The student investigation is the actual hands-on activity performed by the student to facilitate understanding of the concepts. An estimate of the time needed to complete the investigation is provided. (A detailed overview of the student and teacher investigation pages is provided at the conclusion of this sample lesson.)

Action Processing

__ minutes

This component provides teachers with a possible script of questions to enable students to further explore and apply the information and conclusion gained in the investigation. These questions enable the teacher to identify and possibly dispel misconceptions related to the investigations. An important part of this section involves students in revisiting their preconceptions that were recorded in the Prethink section. A time estimate is provided for the activity.

Home Study

This component introduces the Home Study assignment.

CHECKING FOR UNDERSTANDING

Student Reflections

This lesson component provides some suggestions for assessing student understanding of the concepts explored in the lesson. Student reflections are provided to enable students to self assess and reflect on their learning.

Teacher Reflections

Teacher reflection questions are provided to assess the overall learning of the students in the lesson.

EXTENSION

This lesson component provides additional activities, if time permits, for further investigation. These activities enable the student to gain a deeper understanding of the concepts.

OVERHEAD

Overheads

These pages are black-line masters which teachers are advised to photocopy onto transparencies before the lesson begins.

INFO PAGE

Info Page

The Info Page is a black-line master and typically provides reference-type information for students.

STUDENT INVESTIGATION

Student Investigation

These pages are black-line masters that contain student instructions for conducting the investigation (see "Investigation Process," page 14).

ACTIVITY PAGE

Activity Page

The Activity Page is a black-line master; it engages the student in a classroom activity that does not constitute a laboratory-type investigation.

HOME STUDY

Home Study

The Home Study is a black-line master; it provides an additional opportunity for students to apply the lesson concepts while outside of class.

INFO PAGE

TEACHER PAGE

STUDENT INVESTIGATION

TEACHER PAGE

ACTIVITY PAGE

TEACHER PAGE

Teacher Pages

These pages provide the teacher with sample student responses to investigations and/or activities, or they contain instructional tools for the teacher.

Investigation Process

PREPARATION

☐ **Read**

An important step before students perform any investigation is to read the entire investigation sheet. Reading will help students to understand the focus of the investigation and to become familiar with the task(s).

☐ **Background**

After you have discussed and prepared the students for the investigation, students will be asked to discuss the key concepts related to the investigation. In this background section, students should include the scientific principle that the lab is based upon. They should also include a brief statement on the possible discoveries, observed and unobserved, that they might make to better understand the world around them. The length of the background is determined by the depth you require of your students.

☐ **Problem for Student Investigation**

All investigations start with a problem statement. The curriculum provides the question that the investigation will explore. A general question and an oil-specific question are usually provided.

☐ **Prediction/Hypothesis**

Before starting the investigation, students will be asked to make an educated guess about the outcome(s) of the investigation. The prediction/hypothesis statement is written to answer the problem statement. Students are instructed to write their prediction/ hypothesis as a single "If... then...." statement. For example: "*If* a plant is subjected to an environment with no sunlight, *then* the plant will die."

INVESTIGATION

☐ **Materials**

After the students have read the procedure, they are asked to construct a materials list. The intent is to further engage the students in the procedure. Students are reminded to be specific about the types and amounts of materials and supplies needed for the investigation.

☐ **Procedure**

The curriculum includes some investigations that provide the procedure and others that ask students to design their own procedure. When students are asked to design the procedural steps, they should be instructed to be specific enough that another scientist could repeat the lab over in another setting. The usual format is in a list fashion, but students could draw diagrams to help illustrate the steps.

☐ **Data**

Students are asked to record the data that they measure or observe. Data includes information such as time, weights, lengths, color changes, etc. Students record the data in anecdotes, tables, lists, charts, etc. Some charts are provided to facilitate record-keeping, and some are left out so that the students can gain experience in designing their own. Remind students to include the units for all data recorded.

☐ **Results**

Students are asked to summarize their data and note any patterns that emerge. They should not explain the reasons for the data and/or patterns.

☐ **Analysis**

The expected investigation results may not occur for a variety of reasons. In their analysis, students should explain the results of the investigation. This critical review of the data is usually written as an essay, using the data to support and explain possible deviations. The Student Investigation pages provide students with a series of questions to help evaluate the results.

☐ **Conclusion**

The conclusion is designed in two parts. The first is for students to reflect on their prediction, and the second is for students to apply the newly gained information to the curriculum and/or to the outside world. The Student Investigation pages provide focus questions to guide students toward their final conclusion.

Investigation Process

PREPARATION

☐ **Read**

An important step before you perform any investigation is to read the entire investigation sheet. Reading will help you to understand the focus of the investigation and to become familiar with the task(s).

☐ **Background**

You should explain, in essay format, the key concept that this experiment will demonstrate or illustrate. You should include the scientific principle that the lab is based upon. In addition, you should include a brief statement about the possible discoveries, observed and unobserved, that you might make to better understand the world around you.

☐ **Problem for Student Investigation**

All investigations start with a problem statement. This is the question that the investigation will test and answer. This question is based on an anomaly or discrepant event in the world. You usually state the question in one sentence. For example: "Does a plant need....?"; "What is the cause of....?"; "What will happen if...?".

☐ **Prediction/Hypothesis**

Before starting the investigation, you will be asked to make an educated guess on the outcome(s) of the investigation. The prediction/hypothesis answers the problem statement. A prediction/hypothesis is written in a single "If... then..." statement. For example: "*If* a plant is subjected to an environment with no sunlight, *then* the plant will die."

INVESTIGATION

☐ **Materials**

Make a list of all materials to be used during the experiment. Be certain to include the size and type of each object. For example, instead of listing "container," list "100-ml beaker." Also, list the supplies and the amounts needed, such as "20 g of NaCl." Remember, the more specific you can be, the better.

☐ **Procedure**

The procedure lists the steps taken during the investigation. If you are asked to design the procedural steps, then the steps should be clear enough that another scientist could repeat the lab over in another setting. The usual format is in a list fashion, but you can draw diagrams to help illustrate the steps.

☐ **Data**

Record the data that you measured or observed during this lab. Data usually includes time, weights, lengths, color changes, etc. Data is recorded in anecdotes, tables, lists, and charts. Be sure to include the units for all data recorded.

☐ **Results**

Discuss the data you observed and recorded. Note any patterns that emerge. Do not explain the reasons for the data and/or patterns—your explanation of the data will take place later, in the analysis.

☐ **Analysis**

It is very rare to achieve the expected results on a lab, so your task, as a scientist, is to explain why your results might have deviated. Your critical review of the data is usually written as an essay. Use your data to support and explain possible deviations. The Student Investigation pages provide you with a series of questions to help you evaluate the results. In the final analysis, you might want to consider two questions to help focus your essay: (1) Do you have enough data? (2) What data is supporting your analysis?

☐ **Conclusion**

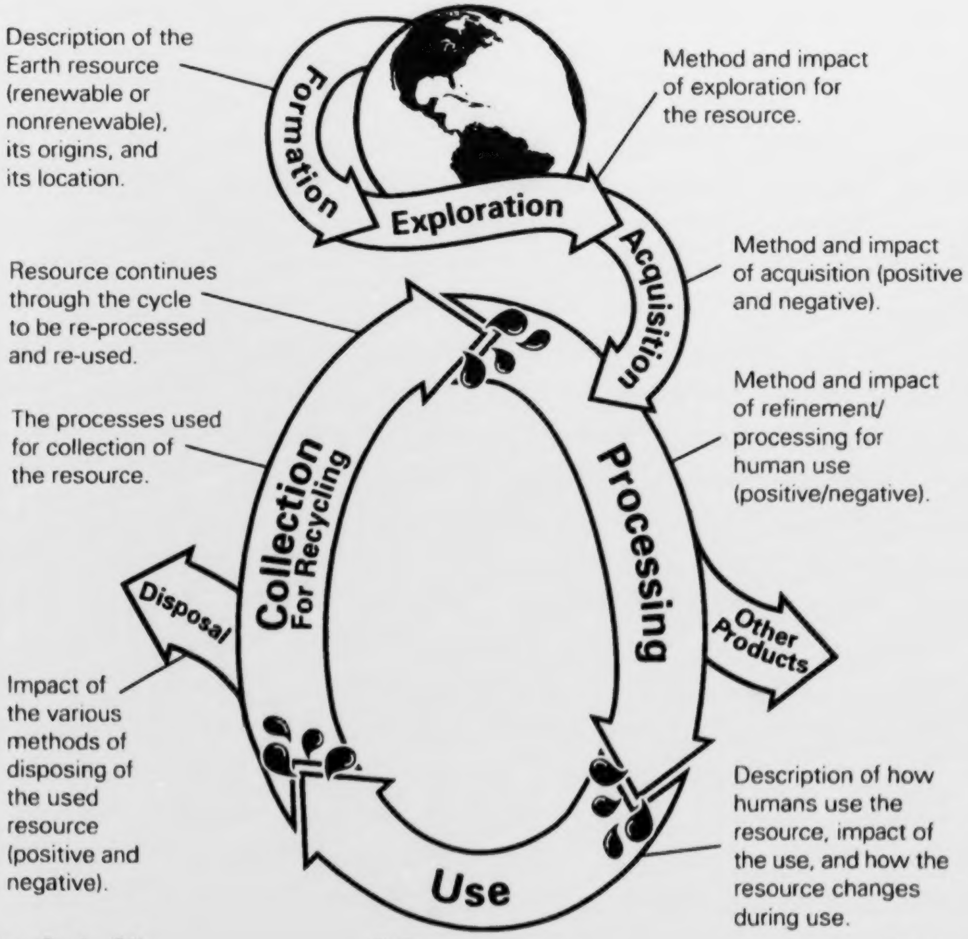
Was your hypothesis proven to be correct or not? Why? What have you learned about the world around you that you did not previously know? What might be the larger applications of this investigation to the greater world? Where can you see this principle or concept applied outside the science laboratory? The Student Investigation pages provide focus questions to guide you toward your final conclusion.

The Earth Resources Cycle

The Earth Resources Cycle is a graphic organizer designed to enable the teacher and students to visualize the stages in the resource cycle. The stages encompass the processes of formation, exploration, acquisition, processing, use, disposal, collection, re-processing, and reuse of an Earth material. The cycle has a variety of instructional uses that can enhance the curriculum, as follows:

- Use the cycle as an overhead transparency to provide the students with a visual depiction of the lessons and the sections as the curriculum unfolds.
- Display the cycle at the end of each section to review and assess student understanding of the processes discussed in the section.
- Have students develop the cycle into a poster to enable them to review the curriculum on their own as the lessons progress.
- Display the cycle to the students at the end of the unit and ask students to create a statement and/or picture to describe the action or process contained in each arrow of the cycle.
- Display the cycle without the words and ask students to fill it in, using their own words and/or pictures to explain the processes represented by each arrow.

A black-line master of the Earth Resources Cycle may be found on page 78.


Description of the Earth resource (renewable or nonrenewable), its origins, and its location.
Formation
Method and impact of exploration for the resource.
Exploration
Acquisition
Method and impact of acquisition (positive and negative).
Resource continues through the cycle to be re-processed and re-used.
Method and impact of refinement/ processing for human use (positive/negative).
The processes used for collection of the resource.
Collection For Recycling
Processing
Disposal
Other Products
Impact of the various methods of disposing of the used resource (positive and negative).
Use
Description of how humans use the resource, impact of the use, and how the resource changes during use.

The Earth Resources Chart

The Earth Resources Chart is a tool designed to enable students to compile their knowledge about a natural resource. The lessons provide students with opportunities to add to their charts as they gather new information.

The primary purpose of the Earth Resources Chart is to provide a record of student knowledge as students progress through the lessons. At strategic points in the curriculum, students are asked to record their collective knowledge about oil on the chart. As they gain more information and/or their preconceptions change, they are able to continue revising and adding to the chart.

The secondary purpose of the chart is to serve as a graphic organizer for the Earth Resources Project — Student Case Study, in which students will research another Earth resource (see page 63). As they conduct their Earth Resources Project, they will complete their own chart for the selected resource in addition to the class chart for oil. Students can use the information on the class chart as a reference while developing their projects.

The following pages contain a master Earth Resources Chart for the entire curriculum, containing only the headers for the chart. To maintain a record of student responses as they progress through the curriculum, you may wish to create overhead transparencies of this master or develop a large classroom poster of the chart.

In addition, on the following pages, a master chart for each section of the curriculum (again, with headers only) is provided for classroom use. Completed portions of the chart with sample student responses are located in Lessons 2, 4, 5, 8, 9, 11, 17, and 18. You might consider either having students create their own charts or, alternatively, providing them copies of the chart for their portfolios, learning journals, or notebooks.

Earth Resources Chart

SECTION 1

Object / Component	Earth Resource	Source of Earth Resource/ Origin	Type of Earth Resource (Renewable or Nonrenewable)	Method of Exploration	Impacts of Exploration		Method of Acquisition	Impacts of Acquisition		Method of Processing	Impacts of Processing	
					+	−		+	−		+	−

SECTION 2

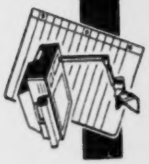
Identify Properties of the Resource	Specific Uses of the Resource	How the Resource Changes During Use	Impacts of Use on the Environment	
			+	−

SECTION 3

Disposal Options for Resource (Loss of Resource)	Impacts of Disposal Options	
	+	−

SECTION 4

Possible Future of Resource	Methods to Reduce, Reuse, and Recycle Resource	Impacts of Reduce, Reuse, and Recycle Options		Actions You/Others Will Take to Make a Difference
		+	−	



Earth Resources Chart

SECTION 1

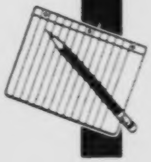
Object / Component	Earth Resource	Source of Earth Resource/ Origin	Type of Earth Resource (Renewable or Nonrenewable)

Method of Exploration	Impacts of Exploration		Method of Acquisition	Impacts of Acquisition		Method of Processing	Impacts of Processing	
	+	−		+	−		+	−

Earth Resources Chart

SECTION 2

Identify Properties of the Resource	Specific Uses of the Resource	How the Resource Changes During Use	Impacts of Use on the Environment	
			+	–



Earth Resources Chart

SECTION 3

Disposal Options for Resource (Loss of Resource)	Impacts of Disposal Options	
	+	−

Earth Resources Chart

SECTION 4

Possible Future of Resource	Methods to Reduce, Reuse, and Recycle Resource	Impacts of Reduce, Reuse, and Recycle Options		Actions You/Others Will Take to Make a Difference
		+	−	

Assessment Strategies

INTRODUCTION

The overall goals of assessment in *Earth Resources — A Case Study: Oil* are to promote the following learning processes:

Learning Processes

Conceptual Understanding	1. Students demonstrate an understanding of the overriding science concepts.
Individual and Team Skills	2. Students actively participate in questioning, sharing and discussing, investigating, record-keeping, and collaborating.
Habits of the Mind	3. Students, when working as individuals or in teams, are capable of showing diverse thinking, curiosity, critical thinking, open-mindedness, respect for different points of view, reflection, and an ability to change their minds when appropriate.

When students meet these goals, they are likely to use their understanding in daily life and to maintain a desire to continue learning throughout their lifetime.

The emphasis on promoting "conceptual understanding" reflects a tradition of research on how students best learn science. When scientific facts are *taught* in isolation of concepts, it has been shown that students cannot use the information and do not retain it over time. Similarly, if scientific facts are *assessed* in isolation of concepts, a teacher cannot know what students really understand about science. For example, on an exam, students might be asked to identify the dark reaction of photosynthesis and correctly fill in its name, "The Calvin Cycle." However, if students do not understand that plants transform energy from the sun into chemical energy that can be used to sustain life, then recalling the name of the dark reaction has little value to them. A question which discerns student understanding of how plants transform sunlight energy into food energy, and why this process is important to life on Earth, would better assess students' conceptual understanding. In this case, correct use of terminology and precise understanding of processes makes the response even better; but conceptual understanding remains the primary focus, as it is this understanding which will encourage students to utilize the knowledge they acquire throughout their lifetimes.

ASSESSMENT OF STUDENT LEARNING IN *EARTH RESOURCES*

A range of assessment strategies has been woven throughout the *Earth Resources* curriculum to provide students with different learning styles an opportunity to develop and demonstrate their conceptual knowledge and skills. Strategies include hands-on experiments, group discussion-based activities, long-term projects, and student reflection on their learning. Taken together, the assessments are designed to address linguistic (the word player), logical/mathematical (the questioner), spatial (the visualizer), musical (the music lover), kinesthetic (the mover), interpersonal (the socializer) and intrapersonal (the individual) learners.

By using a range of approaches, all students' learning styles are addressed, resulting in a level of success for all students. These strategies will at times challenge both teachers who are used to administering — and students who are accustomed to performing successfully on — traditional paper-and-pencil assessments.

The assessment strategies can be used throughout *Earth Resources — A Case Study: Oil* as learning tools to help students toward greater and longer lasting understanding, to help you evaluate their learning, and to provide a context for students to put their knowledge to use. All of the assessments are closely linked to specific lessons and are physically located within the lessons, within each *"Section at a Glance,"* and/or at the end of the entire curriculum.

Assessment Strategies

Within a lesson:
- PETRO-Mail
- Learning Journals

At the end of a lesson or section:
- "Live-at-Five" Interviews
- Concept Maps
- Creative Expression Projects
- Group Evaluations
- Self- and Peer Evaluations

For the entire curriculum:
- Service–Learning Projects
- Portfolios

Taken together, these assessments build on one another. For example, learning journals and student investigations can be used as steps toward the development of the service–learning project; in turn, the learning journals, student investigations, and completed service–learning project can be included in a portfolio. The assessments work together to take students through a conceptual discovery process in which they do the following:

- Discover (find out)
- Analyze (take apart the known)
- Synthesize (put together the known)
- Apply (make use of the known)
- Evaluate (reflect on the learning that has taken place)

For each of the assessment strategies described in the following pages, you will find an overview of the strategy, an assessment action plan, and ideas for evaluation. Portfolios, the final strategy described in this chapter and the suggested overall form of assessment for *Earth Resources — A Case Study: Oil*, can represent an organized collection of a range of assessment activities that have been assigned to students over the course of the curriculum.

TOOLS FOR ASSESSMENT IN *EARTH RESOURCES*

Although a number of "strategy-specific" tools are provided in this chapter after certain assessment strategies, three additional tools with broader applicability have been included at the end of this chapter to help you evaluate your students and keep a record of their achievement. These tools include: (1) *"Levels of Achievement,"* a five-level rubric that can be used to evaluate students' level of achievement and progress on a given assignment (page 44); (2) *"Evaluating Student Performance: Student-Teacher Agreement,"* a tool that can be used to involve students in developing their own five-level rubric (page 45); and (3) *"Habits of the Mind,"* a chart showing how assessment strategies match different learning styles (page 46).

In addition, the *"Teacher Evaluation Form: Self- and Peer Evaluation"* (page 37) provides you with a place to keep a record of student achievement throughout the whole *Earth Resources* curriculum. You can enter the date an activity is assigned, the date it is due, performance levels determined through student self-evaluation, peer evaluation, and/or teacher evaluation, and points assigned. All lessons in the curriculum are listed, even though they may not all be assigned. Individual and team skills and "habits of the mind" are also listed for your evaluation. Open rows at the bottom of the page can be used to write in assessments and special projects that you might assign over the course of the curriculum.

Although all of these tools can be adapted in a variety of ways, they can easily be used "as is" to support the use of many of the assessment strategies described on the following pages.

PETRO-MAIL

PETRO-Mail is a process in which students, as individuals or in groups, write notes to their peers to show their developing understanding of concepts. This strategy involves students in the thoughtful development of questions or factual statements that are, in turn, addressed to their classmates who are then asked to respond. (PETRO stands for: "Protect the Environment, Try Recycling Oil.")

ASSESSMENT ACTION

1. Duplicate and distribute a PETRO-Mail form to each student (a photocopiable master form follows on the next page).
2. Instruct students to write a question or statement that will require other student(s) to demonstrate their understanding of a concept or skill. Students should ask questions that will generate more than single-word responses, using trigger words such as "explain" and "describe" or words leading toward analysis such as "how" and "why." As students practice writing mail, they will improve their questioning techniques.
3. After students have written their mail, you should review what students have written so that you have a sense of the appropriateness of their questions and questioning technique. This gives you the opportunity to check on the general level of understanding among your students. As the "postmaster," you could even invent a "PETRO Postmark."
4. After you review the mail, forward it to a student receiver for a response.
5. The receiver then composes a response, delivers the response to you for review, then you send it back to the original questioner.
6. If the response is incorrect or incomplete, the student who wrote the original question can explain or provide a better answer to the student who wrote the response, or send another PETRO-Mail message.

EVALUATION

PETRO-Mail gives both you and your students an informal strategy for uncovering misunderstandings. You can ask students to save the mail in a portfolio, or you can use it as a checkpoint along the way that receives no formal grading.

PETRO Mail

Try some of these ways to start your message:

Sender's Thoughts

To:	From:	Date:

Message:

Now I understand that...

What I'd really like to know is...

How can I find out about...

An idea I have is...

Something I think is neat is...

PETRO:
Protect the
Environment,
Try
Recycling
Oil

Receiver's Reply

To:	From:	Date:

Message:

I'm frustrated about...

I discovered...

I'm confused about...

I'd like to investigate...

LEARNING JOURNALS

A learning journal allows students to keep a personal record of their thoughts and learning progress. It gives them a place where they are not yet concerned about final products or grades, where they can freely explore ideas, and where their thoughts still can be unstructured. The writing process itself helps students to connect new learning to personal experiences, to previous learning, to current events, or to their concerns and interests. It can be viewed as a sourcebook or a place in which ideas for projects or inquiries can develop and take shape.

Journal-writing can be used before a lesson begins to allow students to think and generate their prior thoughts about the lesson's content. Journal-writing can also be used during the lesson to reflect upon what they have just learned. At the end of the lesson, journals can be used as a self-reflection tool on what students have learned or what they still have questions about. The use and effectiveness of journal-writing depends on the prompt. Suggestions for journal-writing prompts are provided at the end of each lesson, in the Checking for Understanding portion of the lesson.

ASSESSMENT ACTION

Using the questions included in each lesson, or using other questions that you have generated, ask students to write continuously for five to ten minutes or longer. Remind students to avoid editing their own writing, but to instead keep the pen moving, even if they repeat themselves or find that they are writing little that is valuable. You can use the image of "the diamond in the dust heap" to help students to visualize that a learning journal can contain much writing that will never be used, yet reveal occasional moments of real clarity and inspiration.

EVALUATION

Learning journals should not be graded for content, though it is useful to give students incentives for writing in their learning journals, such as a stamp on the journal page, points for effort, or points for meeting the required number of learning journal pages. One evaluation strategy is to ask students to choose one page or paragraph from their learning journal that explains a new project or idea, and to ask for peer or group response on how to develop the project or idea even further. Students can also include their learning journal entries in portfolios.

Example of a Learning Journal Entry

"It seems that I haven't been thinking about how we find oil or how it gets out of the ground. The way it was makes it confusing. I heard that dinosaurs made it but maybe they didn't. Maybe you could explain more to me after school today? I should ask her if she knows more about it. The squeeze box was fun to work with, but it got very messy and got my new pants dirty. I need to be more careful in class."

“LIVE-AT-FIVE” INTERVIEWS

The “Live-at-Five” interview — modeled after the “man-on-the-street” interviews first seen in *Sid Caesar's Comedy Hour* many years ago, and currently seen in prime-time news programs—is a simple, entertaining, and informal assessment used to recognize misconceptions and to assess learning. Students receive challenging questions to answer as a team or as individuals. Collaborating as scientists, they express their thoughts, refine their ideas, and convince others of the validity of their ideas. The goal is for students to explain to the interviewer their answer to a challenging question that has been posed. You can designate one or more students to be an interviewer, or serve as the interviewer yourself.

ASSESSMENT ACTION

Use the questions at the end of each lesson or others that you have developed. Assign one question to each team of students or each individual, then provide students with an opportunity to talk with each other about how they will respond before conducting the “Live-at-Five” interviews.

EVALUATION

While students are discussing their answers, you can monitor their progress by listening in on their conversations and by noting their participation and involvement. This assessment provides you with another opportunity to evaluate individual and team skills and habits of mind while checking for conceptual understanding. As the interviewer moves from team to team, you can evaluate the group's response using the *“Levels of Achievement”* rubric included at the end of this section (page 44).

CONCEPT MAPS

Concept maps allow students to demonstrate their understanding of how ideas relate to each other in a pictorial manner, a technique especially helpful to spatial learners. Concept maps require students to show their understanding of terms and ideas along with the interrelationships among those terms and ideas. After quickly looking at students' concept maps, teachers are able to pinpoint misunderstandings and clear them up before moving on.

Concept maps can be used at various times throughout the curriculum, as follows:

- At the end of a single lesson or activity to help summarize the day's learning
- At the end of several lessons or activities to tie together the learning (at this level the concept map should become very web-like, showing numerous interconnections)
- At the end of the entire curriculum as a culminating assessment
- As an ongoing assignment to be updated after each activity, resulting in one complete map at the end of the curriculum

The three components of a concept map are the key words (usually circled), the arrows that connect the key words, and the linking words written on the arrows.

A sample concept map follows. Sample concept maps for each section are located in each *"Section at a Glance."*

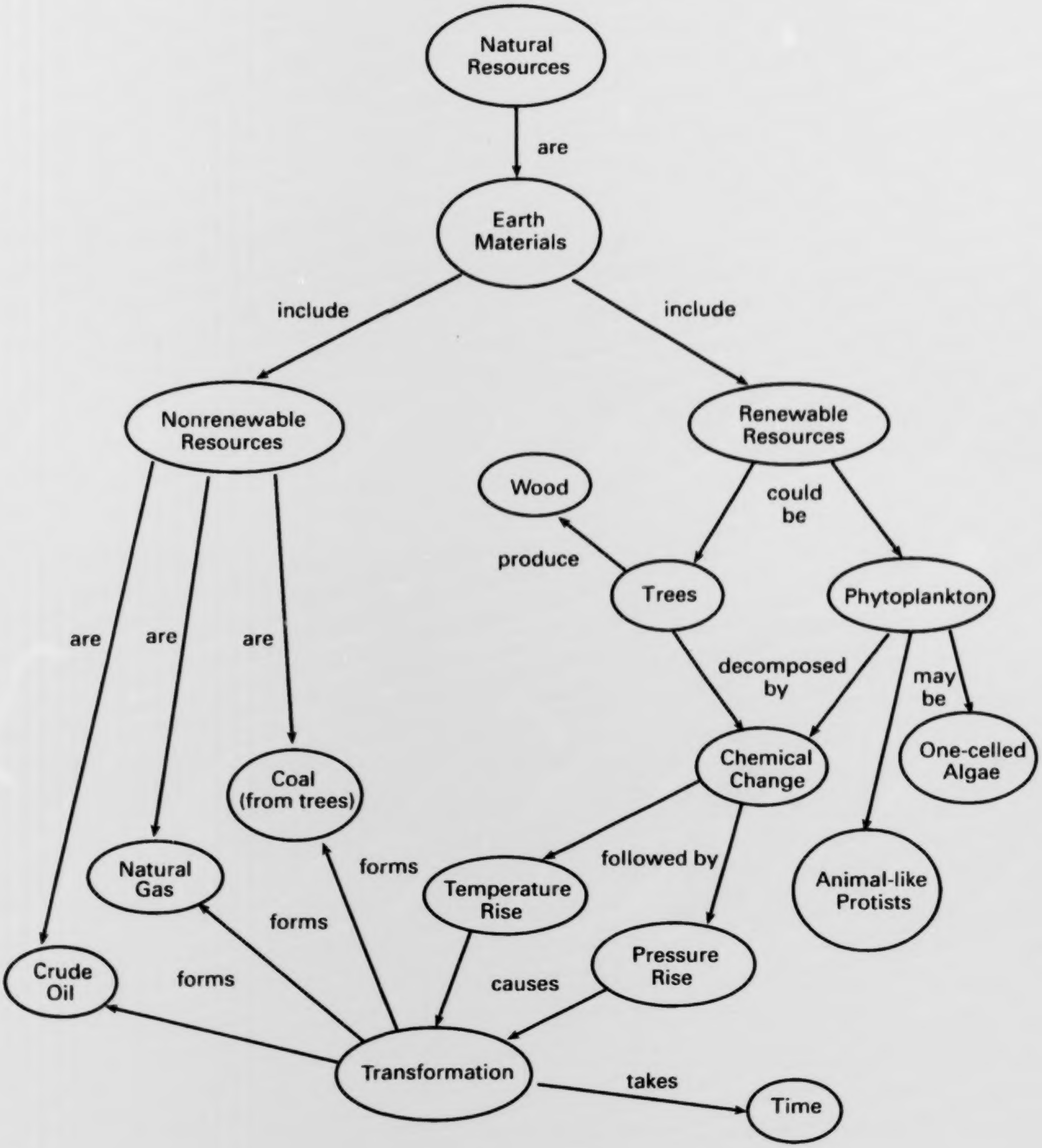
ASSESSMENT ACTION

Construction of a concept map can be an individual, small-group, or large-group activity. One technique is to have students place the key words on self-sticking notes, then move the key words around experimentally until an optimum arrangement is achieved. As students work through this process, ask them to add linking words (usually verbs) that will explain the action connecting the key words. Finally, ask students to draw arrows which indicate how to read the map and the direction in which the information flows. By reading from one key word to the next, along with the linking word, students should make a sentence that states an appropriate concept or relationship between the key words.

EVALUATION

The assessment of concept maps does not need to be time-consuming. Both peer and group evaluation can be used to assess concept maps. Concept maps can also be included in a portfolio and can even represent the conceptual content of the entire portfolio, if used as a culminating assessment. In class, you may also spot-check certain key words to see that they are appropriately linked and take necessary action if misunderstandings remain.

Sample Concept Map


Natural Resources
are
Earth Materials
include
include
Nonrenewable Resources
Renewable Resources
Wood
could be
produce
Trees
Phytoplankton
are
are
are
decomposed by
may be
Chemical Change
One-celled Algae
Coal (from trees)
forms
followed by
Animal-like Protists
Natural Gas
Temperature Rise
forms
Pressure Rise
Crude Oil
forms
causes
Transformation
takes
Time

SERVICE–LEARNING PROJECTS

Service–learning projects provide students with meaningful learning opportunities through community service projects which meet clear community needs. As a facilitator, your role is to guide your students through the process of choosing a project, designing and planning a project, and making the necessary community contacts, while showing them how to cooperatively work in partnership with you, each other, and community organizations. By involving your students in this learning process, they will gain real-world knowledge, make valuable community partnerships, and see the connection between classroom instruction and its real-life application. Projects such as these have the power to help students discover their strengths and interests and to develop leadership skills and cooperative working skills. In turn, students can gain confidence in their ability to bring about positive change through a lifelong engagement with community service.

In Earth Resources, service–learning projects are assigned at the end of the unit. Students' newly gained knowledge can be applied to the task of bringing about a proactive change in public awareness. Projects should not only inform the community of the ecological problems that leakage and improper disposal of used oil can cause, but should also aim to teach the public how to properly dispose of oil and how to facilitate the recycling process by using re-refined oil.

See *"Student Service–Learning Project"* (page 437) for a lesson that focuses on this type of learning opportunity, with examples of service–learning projects.

ASSESSMENT ACTION

To be successful, service–learning projects need to be well organized. Although students should plan the project and be involved in all stages of its development, you will have to guide students and help them find experts in the community with whom they can work in partnership.

To begin, you might ask students to write in their learning journals or discuss in small teams the following questions:

What actions should we take based on our new knowledge?

Who should know about this?

How should we go about educating others?

What would be the best way of getting our message out?

Does the project meet a community need?

What impact might this project have?

What community organization or expert from the community can we work in partnership with?

Does this project have the capability of becoming an ongoing, long-term project?

Once they have done the preliminary thinking and you have offered your advice and feedback, students should go about creating an action plan, designating responsibilities, deciding on contacts to be made, gathering information, and producing a sketch of their product. You will need to prepare your students for making public contacts and coach them in the proper way to greet community members, show telephone manners, and be diplomatic.

(continued on next page)

Throughout the project, you should evaluate the quality, direction, and scope of students' work, making sure that students stay focused and do not take on too large of a task. Periodically, make sure that students are:

- Using scientific research procedures.
- Adhering to their action plans.
- Remaining focused on their project and on their goal to educate others about the importance of recycling used oil.
- Sharing responsibilities, working together cooperatively, and effectively making community partnerships.

The *"Student Service–Learning Project"* lesson which follows Lesson 18 provides tools to help students organize their projects (page 437).

EVALUATION

Students can self-evaluate the success of their projects, using the self-reflection form included in the *"Student Service–Learning Project"* lesson. You might also want to evaluate group dynamics and provide feedback to students on the success of their collaborations. To evaluate the final product, you can use the *"Levels of Achievement"* rubric provided at the end of this chapter (page 44), or ask students to develop their own rubric using the same form as an example. Peers could also use the rubric to evaluate their classmates' products.

CREATIVE EXPRESSION PROJECTS

Creative expression projects give students an opportunity to develop and show their understanding in a non-traditional way. By making a creative project in a format and style of their own choosing, students can integrate scientific knowledge with their artistry and their preferred method of communication. Examples of projects include but should not be limited to: creating and performing a song; writing and performing a play or skit; drawing a picture, poster or cartoon; creating a working or static three-dimensional model; and producing a video.

ASSESSMENT ACTION

Creative expression can be completed by the students in a short or long period of time. A short-term creative expression project would be limited to an activity which could be completed in an evening or class period. In addition, a short-term project should be devised to show a process or single concept and is usually completed by individual students. The directions and mode of expression must be clearly defined. The long-term project would be more involved and completed over an extended period of time. The project could be done by a group to enable students to demonstrate their overall understanding of the section or entire curriculum. To begin a long-term project, you will want to help students to discover their preferred creative mode. Examples of questions you might ask students include:

- What are some of your favorite hobbies?
- What are ways in which you like to express yourself?
- What are some of the different ways that people express their thoughts?

By generating a list of possible creative modes, you can help students to see their options. In addition, you will want to decide whether students will work independently or in groups.

Inform students that they can choose their method of presentation, but they all must demonstrate a clear understanding of the major processes or scientific concepts involved. Remind them that this is a creative project and that any creative mode of expression is encouraged, such as humor, mystery, and cartooning.

Questions will arise about materials the school can provide, about the size or duration of the projects, about storage, and about the amount of money students can spend. You will have to make decisions based on your particular setting, time, and resource constraints. You might also address the possibility of students receiving outside help from parents or from others by sending home a letter describing the project to parents and explaining your expectations. Always encourage parents to oversee the operation of power tools or technology used to construct the projects.

You can ask students to write a learning journal entry about their ideas, to draw preliminary sketches for their project, or to discuss in small groups their ideas. A possible timeline is as follows:

Week One — Students turn in a paper identifying the project, the materials needed, and the steps they must take to accomplish the project. Students also begin researching information they will need to use.

(continued on next page)

Week Two — Students turn in a rough sketch or a rough draft of the project for peer and/or teacher review.

Week Three — Students present projects to the class.

EVALUATION

It can help students to talk about how the project will be evaluated and what criteria will be used to determine its success before they actually begin working. You might consider using the *"Levels of Achievement"* rubric to evaluate projects (page 44). Alternatively, you can ask students to develop their own rubric using *"Evaluating Student Performance: Student-Teacher Agreement"* as a suggested format (page 45).

Begin the rubric-making process by asking students to describe the qualities of an excellent project. Once you have a list of criteria, you can ask students to make a parallel list for a very low performance. The final step is to fill in the middle levels of the rubric. By asking students to make their own rubric, you can help them to understand the criteria for evaluation and to know that evaluation is not an arbitrary or personal judgment about their creativity.

You can also use the rubric to conduct peer, group, and/or teacher evaluation. In addition, the rubric for creative expression projects lends itself to self-evaluation by students. For example, the self-evaluation form on the following page can be used in conjunction with a rubric to evaluate creative expression projects.

Name: ____________________ Date: __________

Project: ________________________________

Self Evaluation:

Creative Expression Projects

1. What parts of your project were especially well done? Why do you think so?

2. What parts of your project do you think could be even better? Why?

3. If you worked in a group, what did you contribute to this project?

4. Using the rubric, what level of performance would you assign to this project? Why?

Level of Performance

GROUP EVALUATIONS

In group evaluations, students work within a group to demonstrate their understanding of concepts and their knowledge of skills and processes. Some students are more at ease in a group and communicate their understanding best when talking and interacting with others. An evaluator observes the interaction occurring within each group, gaining a view of students' understanding that might not be achieved through other assessment strategies.

This strategy helps you, the teacher, to gain insight into the students' understanding of a process or concept either before, during, or after the lesson is completed. Specific examples of group evaluation for each section are listed in each *"Section at a Glance."*

ASSESSMENT ACTION

Two possible strategies for group evaluation are described below: poster session and whiteboard activity.

Poster Session

1. Distribute chart paper.
2. Distribute a marker to each student. (If you wish to evaluate students individually, then distribute a different-colored marker to each student. This provides a quick visual picture for the teacher to assess each individual's contribution.)
3. Provide the instructions:
   - All students are to be actively engaged in the activity or in solving the problem.
   - All students have an equal voice in the decisions of the group.
4. Display the prompt on which you will assess the students. Prompts can be taken from the "Checking for Understanding" sections at the end of each lesson. They can also be specific to a content item to show understanding of an individual concept. For example: What is the process that crude oil undergoes to become refined?
5. Ask students to record the groups' thinking or proposed answer on the chart paper. The recording of information may consist of a picture, concept map, bulleted text, and so on. The group should decide how the recording is to take place. If you are assessing students individually, then you might be more specific about the procedures for responding.
6. All members must sign their finished project to establish ownership in the activity.
7. The group then presents its findings to the class. All students are to take a meaningful part in the presentations.
8. Classroom discussion may be used to clarify the findings or to bring out the main topics of the prompt.
9. Posters may be hung in the room for reinforcement or to provide evidence of the student-centered activity.

Whiteboard Activity

This activity is the same as the poster session, only recorded by the group on dry-erase whiteboards. The whiteboards must be of a size to fit on the top of a table and enable every individual to reach the middle. The drawback of this activity is there is no permanent record of the groups' thinking for future reference or evaluation. The whiteboards may be constructed from white shower board found at most home improvement centers at a very low cost.

SELF- AND PEER EVALUATIONS

Self- and peer evaluations can be valuable learning tools for students because they give students the opportunity to apply criteria to their own and to others' work. Through this decision-making process, students can gain a clearer understanding of what constitutes quality work. It is common to find students who judge their own work more harshly than the teacher, just as it is common to find students who clearly understand the strengths and weaknesses of their peers' work. Through these evaluation processes, students are asked to see their own work more clearly and to take responsibility for improving their work.

Self-evaluation can be especially useful on longer-term projects or creative projects. When students have invested a lot of themselves in a piece of work, self-evaluations can provide a valuable dialogue between the student and teacher, rather than a simple judgment by a letter grade.

Peer evaluations can be especially useful while projects are being made. Peers can often give each other good advice. Peer evaluations, when based on a rubric with clearly defined criteria, can also be useful on final projects.

Peer evaluations can also be used in a variety of ways in the day-to-day classroom. For example, they can be used after a group presentation, group investigation lab activity, short-term creative project, or group problem-solving activity.

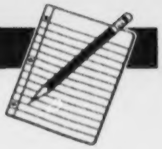
ASSESSMENT ACTION

After completing a project, ask students to answer questions about their own work using a self-evaluation form such as those included in the *"Student Service–Learning Project"* lesson (page 447) and after the creative expression project description in this chapter (page 34). Students can also use self-evaluation questions to describe their rationale for including work in a portfolio and to reflect on their learning.

EVALUATION

If you are using a rubric, the *"Teacher Evaluation Form — Self- and Peer Evaluation"* on the following page has columns to note the rubric descriptors, or scores, that students have assigned to their own work and to the work of their peers. As you make your final evaluation, you can take into account either self- or peer evaluation, or both.

The *"Teacher Evaluation Form — Self- and Peer Evaluation"* can also enable students to chart their progress as they complete the various activities and assignments in the unit. This form can be used in a variety of ways. The top section, listing the lessons, could serve as a cumulative evaluation. Alternatively, as the lessons progress, you may want to pick a period of time or activity that demonstrates a particular skill or thinking process to evaluate. This skill may by re-evaluated at certain points during the curriculum or evaluated over the course of the entire curriculum. As a final self-evaluation, students may use this form to evaluate their progress toward improving various skills they have used in the lessons, then determine their areas of success and areas for continued improvement.



Name: ______________________ Date: __________

Teacher Evaluation Form:

Self- and Peer Evaluation

	Date Assigned	Date Due	Self	Peer	Teacher	Points
1. *As the World Turns: The Earth's Natural Resources*						
2. *Meet Crude Oil: An Earth Resource Case Study*						
3. *Crude Oil Is Trapped: Geologic Processes for Oil Formation*						
4. *Getting Crude Oil: Oil Extraction*						
5. *Crude Oil Becomes Refined: The Role of Distillation in Oil Refining*						
6. *Slipping and Sliding With Oil: The Lubricating Properties of Oil*						
7. *Oil Goes to Work: Lubricating Oil in the Engine*						
8. *Oil, the Pickup Artist: The Cleaning Function of Lubricating Oil*						
9. *Oil's Coworkers: Oil Additives*						
10. *Oil Keeps Clean and Changes: The Role of Oil Filters in the Engine*						
11. *What to Do With Used Oil? Surface Water*						
12. *What to Do With Used Oil? The Backyard*						
13. *What To Do With Used Oil? The Trash Can*						
14. *Why Should We Care About Used Oil? How Used Oil Can Affect the Environment*						
15. *What Difference Can I Make? Exploring Used Oil Collection Opportunities*						
16. *Used Oil Learns the 3 Rs: Recycling, Re-Refining, Reusing*						
17. *New Oil Versus Old Oil: A Qualitative Analysis*						
18. *Earth Resources Case Study: Sharing Solutions*						
Student Service–Learning Project						
Subtotals						

continued on next page

Teacher Evaluation Form: Self- and Peer Evaluation
(continued from previous page)

Name: ______________________ Date: __________

	Date Assigned	Date Due	Self	Peer	Teacher	Points
INDIVIDUAL AND TEAM SKILLS						
Scientific Thinking Skills						
Questioning						
Sharing and Discussing						
Investigating						
Record-Keeping						
Collaborating						
Subtotals						

HABITS OF THE MIND						
Curiosity						
Critical Thinking						
Open-Mindedness						
Respect for Others' Ideas						
Reflection						
Change of Mind						
Subtotals						

ASSESSMENTS/SPECIAL PROJECTS						
Subtotals						

Total Grade ______________

PORTFOLIOS

Through the use of a portfolio, a student can collect and present a selection of his or her work produced during the study of *Earth Resources — A Case Study: Oil.* The portfolio should not be a notebook or collection of all the work the student submits, but instead represent a collection of the student's best work. Because this work is collected over time, the portfolio can include "biographies of work," showing how a work has evolved and progressed. The portfolio also can include a diverse range of products, reflecting a student's unique skills and personality as a learner. The portfolio also provides students with a way of seeing and reflecting upon the whole of their work, demonstrating their understanding of the concepts at the core of the curriculum, their growth, and their interests.

Unlike some other forms of assessment, portfolios provide opportunities for students to:

- *Revise*
  Students can redo or revisit previous work to show deeper understanding of scientific concepts; they can show work-in-progress (research notes, rough drafts, final drafts) and revise this work over the course of the unit.
- *Collaborate*
  Students can work in collaborative groups with classmates to accomplish a task or they can interview adults to gather information.
- *Show Growth Over Time*
  Students can show a deeper understanding of concepts by relating an activity to information derived from earlier learning experiences. They can also show increased knowledge or skill in their work.
- *Establish Relevancy*
  Students can show how their work relates to scientific, technological, and societal issues or they can relate the work to implications in their own lives.
- *Show Interdisciplinary Connections*
  Students can incorporate skills and knowledge gained across the curriculum, including math, social science, and language arts; students can also use various media (music, art, video, computers, poetry, cartoons, essays, etc.).
- *Self-Evaluate*
  Students can reflect on their own learning and gain experience thinking critically about their own work.
- *Individualize Assessment*
  Students can choose what to submit, indicating their own perception of their achievement and giving the teacher a deeper understanding of the student as a learner; students can compare their work to performance standards rather than to other students' work.

Portfolios can have different purposes. In addition, the representative contents of each portfolio will vary, depending on the specific idea or concept of the portfolio. The purpose of the portfolio must be decided by the student and/or teacher and demonstrate growth or progress in a definite way. The following are some examples of different aspects of work that can be encompassed by portfolios:

- *Growth in Experimental Design*
  Students would include four to five investigations that they had designed to demonstrate the increased sophistication in each activity's design.
- *Growth of a Concept*
  Students would include their initial thoughts on the topic, what they want to know, what they had found out, and evidence that they had, indeed, increased their level of understanding and can apply the concept.
- *Growth in Academic Achievement*
  This portfolio could take many paths. For example, to demonstrate students' conceptual learning, this type of portfolio might contain essays,

on-demand tests and assessments, peer or self-evaluations, or any other type of evidence that would show attainment of the concepts. Some type of beginning, middle, and ending benchmark must be cited to clearly demonstrate growth in the chosen area. This portfolio is more cumulative in nature than portfolios that are compiled for other purposes.

- *Exploration of a Problem*
  Students would demonstrate their understanding of the problem, their research and newly gained knowledge about the problem, and the possible solution to the problem. This type of portfolio could be used to document the Earth Resources Project — Student Case Study or the service learning project.

ASSESSMENT ACTION

In their portfolios, students can include learning journal entries, drafts, research or interviews of experts, completed projects, extended investigations, performance tasks, or any other product created throughout the course of study. However, it helps to identify categories in which students should select samples of work. For example, you could ask students to include one entire project, including notes, research, drafts, and final draft; selected learning journal entries; the final draft of a second project; and evidence of their work during two lessons. From those categories, students can make choices about what to include in their portfolio.

Once students have selected their work, they should answer the self-evaluation questions on *"Portfolio Self-Reflection"* (page 41). Encourage students to write as much as they can and to try to give in-depth responses. You can ask students to create a cover for their portfolio. You can also ask them to write a letter introducing their portfolio to a prospective employer, explaining how their work illustrates their competence and understanding; or a letter to a peer, explaining how the work illustrates their talents and interests.

If you are using the entire *Earth Resources* curriculum, you might want to begin the process by asking students to reflect on the following questions:

> *How were the Earth's natural resources formed?*
>
> *How does the disposal of used natural resources affect the environment?*
>
> *What can be done now to conserve natural resources for future generations?*

Revisit these same questions at periodic intervals throughout the course of study so that students can show growth in their understanding of the concepts and processes that they are learning. At the end of the curriculum, you might consider asking students to write a concluding essay on a topic to summarize their learning.

If you are using only part of the curriculum, you can ask students to explain what they know about the topics being studied both before and after the course of study, and include these statements in the portfolio as evidence of growth.

EVALUATION

Scoring the portfolio holistically requires some practice, but it can be facilitated through use of the *"Portfolio Scoring Guide,"* a four-level rubric that describes levels of achievement for specific student skills and conceptual understandings (page 43). The individual portfolio entries are graded during the course of study. The overall portfolio score is based on the quality and thoughtfulness of the composition (i.e., the student's selection of work samples) and on the student's self-reflections on those samples.

Name: ______________________ Date: __________

Portfolio Self-Reflection

I have chosen to place this entry in my portfolio because it shows...

I am proud of this work because...

If I were given the chance, I would improve my work by...

This entry is related to these scientific concepts:

This entry relates to the real world because it...

If this was a group project, my contribution would have been...

What I like best about this activity is...

This activity tells you that I...

Portfolio Self-Reflection

I have chosen to place this entry in my portfolio because it shows...

Answers will vary. The student response should be a statement that describes the quality of the work, making references to the scoring guide as applicable.

I am proud of this work because...

Answers will vary.

If I were given the chance, I would improve my work by...

Answers will vary. However, the response should give specific examples of areas of improvement.

This entry is related to these scientific concepts:

Answers will vary, but all should reference the relevant scientific concepts.

This entry relates to the real world because it...

Student responses should cite specific examples of connections to the student's life, to society, or to technology.

If this was a group project, my contribution would have been...

Student responses should show that they helped make decisions in planning and organizing the project, shared information and ideas, helped others to learn and become involved, helped to complete the work well, and took responsibility for their own learning and for the learning of others.

What I like best about this activity is...

Answers will vary.

This activity tells you that I...

Answers will vary.

Portfolio Scoring Guide

Level 4

Student work at this level shows insightful reflection and mastery of scientific concepts and principles. There is strong evidence that items have been revisited and improved to reflect newly gained knowledge, skills, and increased depth of understanding. Laboratory or field work shows excellent experimental design and accurate data collection. Analyses show a high level of reasoning. Evidence of productive collaboration that shows improved understanding is present. Student work shows insightful and relevant applications of science to daily life and thoughtful, valid relationships among the disciplines of science and between science and other disciplines. All aspects of the tasks are complete and contribute to the overall excellence of the portfolio. Student work displays creativity and excellent communication skills.

Level 3

Student work at this level shows thoughtful reflection and strong understanding of scientific concepts and principles. There is evidence that items have been revisited and improved to reflect newly gained knowledge, skills, or increased depth of understanding. Laboratory or field work shows strength in experimental design and appropriate data collection. Analyses show a moderately high level of reasoning. Evidence of productive collaboration that shows improved understanding is present. Student work shows relevant applications of science to daily life and valid relationships among the disciplines of science and between science and other disciplines. All aspects of the tasks are complete and contribute to the overall quality of the portfolio. Student work displays creativity and strong communication skills.

Level 2

Student work at this level shows some reflection and basic understanding of scientific concepts and principles. There is limited evidence that items have been revisited or improved to reflect newly-gained knowledge, skills, or increased depth of understanding. Laboratory or field work shows basic skills in experimental design and data collection. Analyses show limited reasoning. Evidence of collaboration attempts to show improved understanding. Student work shows applications of science to daily life or some relationships among the disciplines of science and between science and other disciplines. Most aspects of the tasks are complete. Student work demonstrates limited creativity and basic communication skills.

Level 1

Student work at this level shows limited reflection and little or no understanding of scientific concepts and principles. There is minimal evidence that items have been revisited or improved and may not reflect newly gained knowledge, skills, or increased depth of understanding. Laboratory or field work shows minimal skills in experimental design and data collection. Incomplete analyses and flawed reasoning may be present. Evidence of collaboration may not show improvement in understanding. Application of science to daily life or other disciplines is minimal. The incomplete presentation displays little or no creativity, and errors in expression limit effective communication.

Adapted from the Golden State Examination Science Portfolio Pilot Generalized Scoring Guide, 1993.

Levels of Achievement

Each of the following levels of achievement indicates increasing improvement of student performance in *Earth Resources — A Case Study: Oil*, with a "5" serving as the highest level of performance. These levels can be used with any type of ongoing or embedded assessment. The descriptors describe how well students have learned and understood the concepts contained in *Earth Resources — A Case Study: Oil*. In using this rubric, keep in mind that a student may have reached a top level of performance in one activity, yet score at a low level in a following activity, therefore individual scores do not necessarily represent increased proficiency. To measure a student's overall proficiency level, his or her scores should be totaled.

1

At this level of proficiency, the student has incorrect or negligible ideas about oil. The ideas expressed by the student are based on faulty reasoning rather than correct scientific information. The student's prior knowledge and conceptions have been influenced by incorrect experiences or information. The student is performing at a minimal level on individual and team skills and is minimally proficient in habits of the mind. The student may even disrupt the flow of learning within his or her group.

2

A student at this level of proficiency has challenged his or her pre-existing ideas through new experiences, yet conceptual change has not completely occurred. The student's knowledge is based on mere recall, and the student exhibits minimal understanding. He or she is exercising some of the individual and team skills and habits of the mind, but has not completely adapted them.

3

This level describes a student who has experienced challenging scientific experiences that have caused the student's pre-existing concepts to change. The student understands the new information and has collaborated with others enough to understand that there are other ways of thinking, performing, and investigating. The student has begun to use some of these behaviors with only occasional prompting.

4

At this level the student has begun to demonstrate the desired knowledge and behaviors without prompting. The student can take apart information she or he has learned and reconstruct it with correct meaning. Most of the time, the student is independent and self-motivated to perform individual and team skills and exercise habits of the mind.

5

At this level of proficiency, the student excels at the knowledge level of performance. The student uses creativity and critical analysis to process information and to refine his or her knowledge. This student consistently exhibits individual and team skills and habits of the mind. The student prompts and encourages other students to do the same, and therefore often serves as a group leader.

Evaluating Student Performance:
Student-Teacher Agreement

Performance Standards

Score	Content Criteria
5	
4	
3	
2	
1	

Habits of the Mind

	Linguistic	Logical	Spatial	Musical	Kinesthetic	Interpersonal	Intrapersonal	Benefits
Concept Maps	X	X	X			X	X	Students show conceptual understanding.
Service Learning	X	X	X	X	X	X	X	Students become proactive in the community.
Creative Expression	X	X	X	X	X	X	X	Students show understanding using different media.
Portfolio	X	X	X	X	X	X	X	Students show what they know and what they can do.
PETRO-Mail	X	X	X			X	X	Students communicate with others.
Live-at-Five Interviews	X	X			X	X	X	Students share ideas with others.
Learning Journal	X	X	X			X	X	Students reflect on learning through directed questions.
Group Evaluation	X	X	X		X	X	X	Students collaborate to produce work as a team.
Self/Peer Evaluation	X	X	X			X	X	Students take time to reflect on quality of work.
Action Processing	X	X	X	X	X	X	X	Students use concepts learned to answer directed questions.
Student Investigation	X	X	X			X	X	Students discover concepts through hands-on activity.
Performance Task	X	X	X		X	X	X	Students use accumulated knowledge to solve a problem.
Resource Chart/Cycle	X	X	X		X	X	X	Students interact with information in a visual way.

Section at a Glance: *Section 1*

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interaction of matter and energy.

SECTION 1 OVERVIEW

The first section focuses on the formation, exploration, acquisition, and processing of crude oil.

SECTION 1:
Locating, Acquiring, and Processing Our Earth's Resources

Section Concepts

Human: Natural resources are used by human populations in order to maintain and improve their existence.

Scientific: The Earth's natural resources are formed over time. These resources have observable physical and chemical properties.

LESSON OVERVIEWS

Lesson 1

As the World Turns: *The Earth's Resources*

Students explore their prior knowledge about how humans use Earth resources to maintain and improve their existence. Students identify Earth resources used to manufacture items and identify whether they are renewable or nonrenewable. Students explore the positive and negative impacts of processing resources into useful materials.

Lesson 2

Meet Crude Oil: *An Earth Resource Case Study*

Students explore crude oil, its origins, and the stages of its formation. Students analyze the rate of petroleum consumption and the need to manage resources.

Lesson 3

Crude Oil Is Trapped: *Geologic Processes for Oil Formation*

Using a squeeze box, students investigate how geological processes have contributed to the accumulation of crude oil under certain types of geological conditions.

Lesson 4

Getting Crude Oil: *Oil Extraction*

Students discuss issues surrounding the acquisition of natural resources. Students explore the difficulties of crude oil extraction. Students simulate crude oil extraction.

Lesson 5

Crude Oil Becomes Refined: *The Role of Distillation in Oil Refining*

Students investigate the separation of liquid mixtures by distillation and relate this process to the refining of crude oil.

Earth Resources Project — Student Case Study

Students select an Earth resource, other than oil, on which to conduct research for their own case study. After each section, students spend a class session researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	**Lesson Concept**	**Scientific Thinking Processes**	**Desired Outcomes** *Students will…*
LESSON 1. **As the World Turns:** *The Earth's Resources*	Human populations use renewable and nonrenewable resources in order to maintain and improve their existence.	• Comparing • Ordering • Categorizing • Relating • Applying	*Explore* the notion that Earth resources have been and will continue to be used to maintain human populations. *Identify* that most manufactured objects are constructed from Earth resources. *Determine* whether common objects are made of renewable and/or nonrenewable Earth resources.
LESSON 2. **Meet Crude Oil:** *An Earth Resource Case Study*	The Earth's resources are formed over time and can be changed physically and chemically through natural processes. Increasing human consumption depletes the finite resources of the Earth.	• Observing • Communicating • Comparing • Ordering • Categorizing • Relating • Inferring	*Classify* Earth resources as renewable or nonrenewable resources. Students will *determine* that oil is a nonrenewable resource. *Infer* that human consumption of Earth resources depletes resources that are nonrenewable. Students will *infer* that humans are depleting crude oil reserves. *Show* how an Earth resource is composed of basic "ingredients" which undergo physical and chemical changes over time. Students will *relate* that oil is formed over time through a series of chemical changes. *Determine* the basic stages in the formation of an Earth resource. Students will *describe* the stages of crude oil formation on Earth over millions of years.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	**Lesson Concept**	**Scientific Thinking Processes**	**Desired Outcomes** *Students will…*
LESSON 3. **Crude Oil Is Trapped:** *Geologic Processes for Oil Formation*	Tectonic forces cause the Earth's structure to be dynamic, creating new geologic formations.	• Observing • Communicating • Comparing • Ordering • Categorizing • Relating • Inferring • Applying	*Describe* how Earth resources are formed and deposited. Students will *describe* the relationship between the deposition of sedimentary layers and the formation of crude oil. *Give examples* of the formation of Earth resources through geologic processes. Students will *explain* how geological processes have contributed to the accumulation of large volumes of crude oil. *Infer* the location of Earth resources. Students will *infer* the location of crude oil.
LESSON 4. **Getting Crude Oil:** *Oil Extraction*	Physical and chemical properties facilitate human extraction of natural resources.	• Observing • Communicating • Comparing • Relating • Inferring • Applying	*Demonstrate* how Earth resources are acquired. Students will *conduct* and *manipulate* a model for extracting oil. *Identify* economic and environmental issues related to the acquisition of Earth resources. Students will *describe* the economic and environmental issues related to oil extraction.
LESSON 5. **Crude Oil Becomes Refined:** *The Role of Distillation in Oil Refining*	Humans use materials based upon their physical and chemical properties.	• Observing • Communicating • Comparing • Ordering • Categorizing • Applying	*Describe* distillation as the separation of a mixture of two or more components through the process of vaporization followed by condensation. Students will *discuss* the use of distillation in separating the components of crude oil. *Describe* the relationship of boiling points to separation. Students will *describe* how a difference in boiling points is used to separate the components of crude oil.
Earth Resources Project — *Student Case Study (Research Day)*	All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.	• Observing • Communicating • Comparing • Ordering • Categorizing • Relating • Inferring • Applying	*Identify* questions and concepts about an Earth resource. *Design* and *conduct research* on an Earth resource. *Formulate, revise,* and *synthesize* the newly gained information. *Recognize* and *analyze* alternate explanations and models about an Earth resource. *Begin creating* a presentation about an Earth resource.

Getting Ready For Section 1

Lesson 1
As the World Turns: *The Earth's Resources*

What You Will Need

For the class:

- Selection of samples, such as:
  - aluminum (e.g., aluminum cans)
  - glass (e.g., bottles and jars)
  - paper (e.g., pieces of paper, box)
  - plastic (e.g., bag, bottle)
  - steel can
- References related to Earth resources (CD-ROM, encyclopedias, etc.)

For each group of students:

- Chart paper
- Markers or felt-tipped pens

Lesson 2
Meet Crude Oil: *An Earth Resource Case Study*

What You Will Need

For the class:

- Sample of mineral oil in a clear container
- Sample of motor oil in a sealed, clear container
- Videotape, *Fuel-Less*
- Pictures and/or diagrams of marine plankton
- Microscopes
- Prepared slides of the actual or skeletal remains of marine plankton (diatoms or algae)
- Prepared slides of partially decomposed organic matter (optional)

For each group of students:

- Markers
- Sealed container/baggie of partially decomposed organic matter, from a pond or compost pile
- Hand-held lenses
- Envelope of "Formation of Crude Oil" strips (mixed up)

Getting Ready

☐ Collect diatoms and other plankton (i.e., algae) from a stream or the ocean, or if unavailable, mix water with diatomaceous earth.

☐ Collect a sample of partially decomposed organic matter (at least 1 liter) from the bottom sediment of a nearby pond or compost pile (the material should have a dark, mucky appearance). If available, also collect a sample of material that is less decomposed to compare with the older material.

☐ Prepare slides of diatoms, using diatomaceous earth, or algae.

☐ Prepare slides of partially decomposed organic matter (optional).

☐ Post pictures/diagrams and geological time charts in the classroom and display samples of motor oil.

☐ For each group, prepare a sealed container or baggie of decomposed organic material.

☐ Obtain a TV/videotape player and queue video if necessary.

Lesson 3
Crude Oil Is Trapped: *Geologic Processes for Oil Formation*

WHAT YOU WILL NEED

For the class:

- Sedimentary bottle (tall, capped, transparent bottle containing water and shallow layers of sand, mud and various sizes of pebbles)

For each group of four students:

- Simulated sediment, such as damp samples of clay, soil, fine and course sand
- Diatomaceous earth
- Spoons and scoops
- Newspapers to cover desks
- Tape
- Scissors
- Paper
- Colored water
- Squeeze box (see lesson for instructions and materials)
- Cardboard from the back of a writing tablet cut to the size of the bottom of the squeeze box plus 1-2 cm. in length
- Plastic wrap to cover the cardboard
- 4 tacks
- Clear, rigid tubes; clear thermometer cases; or very sturdy, clear straws

Getting Ready

☐ Make squeeze boxes (prepare one of them with layers of sediment; instructions are shown in the lesson).

☐ Add water to the different materials that will act as sediment so they hold together but are not soggy.

☐ Add colored water to the diatomaceous Earth until it is *very* wet.

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Lesson 4

Getting Crude Oil: *Oil Extraction*

WHAT YOU WILL NEED

For the class:

- Pictures of oil wells

For each group of students:

- Newspaper
- Ring and ring stand
- Cold water
- 1 clear plastic bottle with pump nozzle (such as a hand soap bottle) and plastic tubing that extends into the bottle
- 1 piece of tubing, 30-40 cm long, to fit the delivery end of the plunger
- 1 100-mL graduated cylinder
- 1 funnel
- 50 to 100 mL cooking oil
- 50 to 100 mL small, clean pebbles (to cover the oil)
- 2 sheets of graph paper
- Exploration materials (i.e., distractors) such as hot water, liquid soap, saw dust, etc.
- Cheesecloth
- Rubber bands

Getting Ready

☐ Determine the amount of oil and water to be added to the pumper in Parts 1 and 2 of the investigation. The amount will vary depending on the size of the pumper and depth of the pump.

☐ Determine spill or cleanup procedures for accidents at the lab stations.

Lesson 5

Crude Oil Becomes Refined: *The Role of Distillation in Oil Refining*

WHAT YOU WILL NEED

For the class:

- 1 liter jar of muddy water
- 1 liter jar of gravel/sand mixture
- 1 liter jar of water
- Sugar
- Funnel and filter paper
- 1 wire screen with mesh size between that of the sand and the gravel
- 1 pan
- Lab setup for the boiling and condensation of water to demonstrate to students
- Small quantity of rubbing alcohol
- Beaker or small glass container
- Small quantify of water
- Samples of petrochemical products (i.e., CD cases, cosmetics, credit cards, paint thinner, kerosene, paraffin wax)

For each student:

- 2 sheets of graph paper

For each group of two students:

- 50 mL of a 1:1 mixture of rubbing alcohol and water
- Ice
- 2 pairs of safety goggles
- 1 250-mL Erlenmeyer flask
- 1 thermometer, 0 - 110° C range
- 2 50-mL graduated cylinders
- 1 two-holed stopper to fit the flask
- 1 400-mL beaker for ice
- 1 ring stand and ring
- 1 piece of rubber hose, 60-80 cm long
- 1 wire gauze
- Boiling chips
- 1 hot plate (or gas burner)
- 1 utility clamp
- 1 glass tube, bent

Getting Ready

☐ Assemble one distillation setup to serve as a model.

☐ In the interest of safety and time, you may wish to construct the stopper-thermometer-tubing-tube setups for each group beforehand.

☐ Prepare the mixture of rubbing alcohol and water mixture in a 1:1 ratio. Make 50 mL per lab station.

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Earth Resources Project — Student Case Study
(Research Day)

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

Getting Ready

☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).

☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.

Storyline

An interesting way to start the study of Earth resources is to actively involve students from the beginning. One suggestion is to start with a short "play" that sets the scene. The Section 1 storyline will involve six students in role-playing the characters and performing this skit in front of the class.

ANALYSIS OF A RESOURCE: PART 1

An Oily Beginning

Characters: Mom, Dad, their teenage children — Andrea (17), Elias (15), Cecylia (13) — and the narrator

Narrator: As the family drives along Highway 1 through the redwood forest in Northern California, a discussion on modes of transportation arises. Cecylia, the imaginative teenager, comes up with an innovative method of transportation.

Cecylia: Wouldn't it be great if we just had to "think" ourselves from one place to another? We wouldn't need cars, so there wouldn't be any junk cars lying around. Dad wouldn't have to worry about whether he was going to get a flat tire on our vacation. We wouldn't have tow trucks or pollution from vehicles.

Elias (always the practical one): But Cecylia, think about all the jobs that would be lost!

Cecylia: Would you stop progress because of the loss of jobs? Think about it, Elias, if some jobs were lost, others would be created.

Andrea: Yeah, Elias, don't be an airhead. Let's think about what jobs could be created from Cecylia's new transportation method.

Narrator: The car begins to slow.

Andrea: OK, Dad. Did you forget to fill the gas tank? Are we out of gas? Do you realize there aren't any tow trucks or gas stations for miles? Cecylia's idea about mental transportation isn't sounding too bad right now!

Mom: Andrea, we're not out of gas. Look at the traffic ahead. All the cars are stopped on both sides of the road. I wonder what is going on.

Dad: There's a policeman. I think I'll go ask what the problem is.

Narrator: Dad gets out of the car to talk to the policeman. When he returns, he is frowning, and he has some bad news.

Dad: There's been an accident up ahead. A tanker truck collided with a logging truck. The tanker is leaking some gooey stuff into the river. The diesel tank on the logging truck has been punctured and the logs have rolled off the truck. They are covered with the goo. Not only is there a tremendous danger of fire but the river is being badly polluted. They want us to turn around and go back. We will not be able to get through on this road for several days.

Mom: Wasn't there a town a few miles back?

Andrea: Mom, that town is down river from this accident. Won't the residents get the polluted water?

Elias: That's right. Has someone warned them?

Cecylia: Say, Dad, you're an engineer. Why don't you offer to help? You could come up with a way to stop the polluted water from reaching the town!

Dad: No!!! Your safety is most important to me right now. Besides, it would take more then one person to do that.

Narrator: Dad turns the car around and they drive back in the direction from which they had come. After a brief time, Cecylia, who has been thinking about this accident, starts asking questions.

Cecylia: Dad, didn't the policeman say that diesel was spilled?

Dad: Yes, Cecylia, he did. You know that diesel fuel and gasoline come from crude oil.

Cecylia: I knew that. We learned it in science last year. The crude oil is what we extract from the ground or the ocean floor. After the crude oil is extracted from the ground, it is distilled to produce lots of things. One of those things is gasoline, another is diesel fuel.

Dad: You are correct to a point, Cecylia. But it must be transported before it can be refined — which is the correct term for the distillation of crude oil. Then the products must be transported to places where they can be sold.

Elias: We use a lot of gasoline to transport hazardous chemicals and stuff. It can be a fire danger, or a pollutant if it gets into the water. By the way, Dad, who will clean up the water and how will they do that?

Dad: To answer your question, Elias, there are specially trained people who can clean up all kinds of spills. Many precautions are taken when transporting hazardous materials to prevent spills from occurring in the first place. But in spite of all the safety precautions, accidents still happen.

Cecylia: Well, Elias, what do you think of my idea now for just "thinking" ourselves to another place, instead of having to drive there? At least my creative suggestion would eliminate the hazard of transporting hazardous materials!

Elias: Yeah, I see your point. But we also need to think about how we use natural resources everyday and how it affects the environment. Why don't we take a closer look at these resources and how they are turned into products we use?

Suggested Strategies for Assessment

Section 1

PETRO MAIL

To use this assessment activity, you can engage your students in one of three ways:

- Ask students to generate questions to quiz other students on the individual lesson concepts or on section concepts.
- Use one of the writing prompts provided in the Checking for Understanding section found at the end of each lesson to review other students' conceptual understanding.
- Generate specific questions or writing prompts to assess students' knowledge of a specific concept in the lesson or section which you stressed.

Additional information on "PETRO Mail" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LEARNING JOURNALS

Using the writing prompts and questions found in the Checking for Understanding section, or using other prompts you have generated, have the students write continuously for 5 to 10 minutes.

Additional information on "Learning Journals" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LIVE-AT-FIVE INTERVIEWS

To use this assessment activity, you can engage your students in one of two ways:

- Have students interview a person as if he or she were an atom at the beginning of time, tracing the path of the Earth's evolution. Sample interview questions might include the following:
  - What was it like when you were just an atom during the earliest stages of the Earth?
  - What happened when the Earth's layers of rock were forming?
- Have students interview an oil expert. Sample interview questions might include the following:
  - How was oil formed?
  - How do you explore for oil deposits?
  - How is crude oil removed from the Earth?
  - How does your company extract crude oil from the Earth?
  - What problems did your company face when they removed the oil? How did your company overcome the problems?

Additional information on "Live-at-Five Interviews" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CREATIVE EXPRESSION

To use this assessment activity, you can have students implement one of the following short-term or long-term projects:

Short-Term

- Using the squeeze-box activity, write a creative essay from the perspective of a rock, describing the processes that changed the layers of the Earth.
- Draw a cartoon from the perspective of a molecule of an Earth material as it changes into a manufactured item.
- Make a diorama on the formation of the Earth.
- Create a poster or timeline on the formation of an oil deposit.

Long-Term

- Create a video or skit on the formation, exploration, extraction, and refinement of oil.
- Write a creative essay or draw a full cartoon on the formation, exploration, extraction, and refinement of oil from the perspective of an oil molecule.

Additional information on "Creative Expression" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

GROUP EVALUATION POSTER SESSION OR WHITE BOARD

This activity can help you gauge students' preconceptions before each lesson begins or during the Prethink portion of each lesson. Save the poster for review at the end of the lesson. If you do this activity on white boards, have the students record the ideas in their learning journals. You should refrain from adding information or correcting the students' statements. While students review their prior thinking during the Action Processing section of each lesson, you may want to ask questions to enable the students to dispel the misconceptions shown on the posters.

Sample prompts include:

- Discuss the formation of oil deposits.
- How do oil companies extract crude oil?
- Explain the process of refining crude oil and the products that are obtained.

Additional information on "Group Evaluation Poster Session or White Board" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

PORTFOLIOS

Before the student can begin collecting entries for the portfolio, students and/or teacher must decide the purpose of the portfolio. After the purpose and number of entries are decided, students should take the following steps:

- Make their first selections.
- Generate some initial thoughts for their topics.
- Self-reflect as to why they chose the entry.
- Determine what they know about the chosen subject.
- Decide what they want to know about the chosen subject.

If you are using this curriculum as the organizer for the portfolios, you might begin the process by asking students to reflect on these questions:

- How does the Earth form and recycle its natural resources?
- What effects can the disposal of used natural resources have on the environment or on the Earth's systems?
- What can be done now so that we will have natural resources available for use in the future?
- How does the human use of a natural resource affect the Earth and its systems?
- What is meant by *renewable* and *nonrenewable resources* of the Earth?

Additional information on "Portfolios" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CONCEPT MAPS

To use this assessment activity, try one of the following ideas:

- Have students generate a list of high-frequency or key terms used in the day's activities or lessons, and then have them use this list to construct a concept map.
- Generate a list of key terms which you have determined to assess the students' conceptual understanding of the lesson, and then have students generate a concept map that includes these key terms.
- Use the following concept map to assess your students' conceptual understanding of the section. Provide your students with copies of *"Activity Page — Earth Resources Concept Map for Section 1."* Have your students fill in the blank concept map, using the list of key terms used. You may wish to fill in a few of the key terms to get students started. Use the corresponding Teacher Page to assess students' understanding.

Additional information on "Concept Maps" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

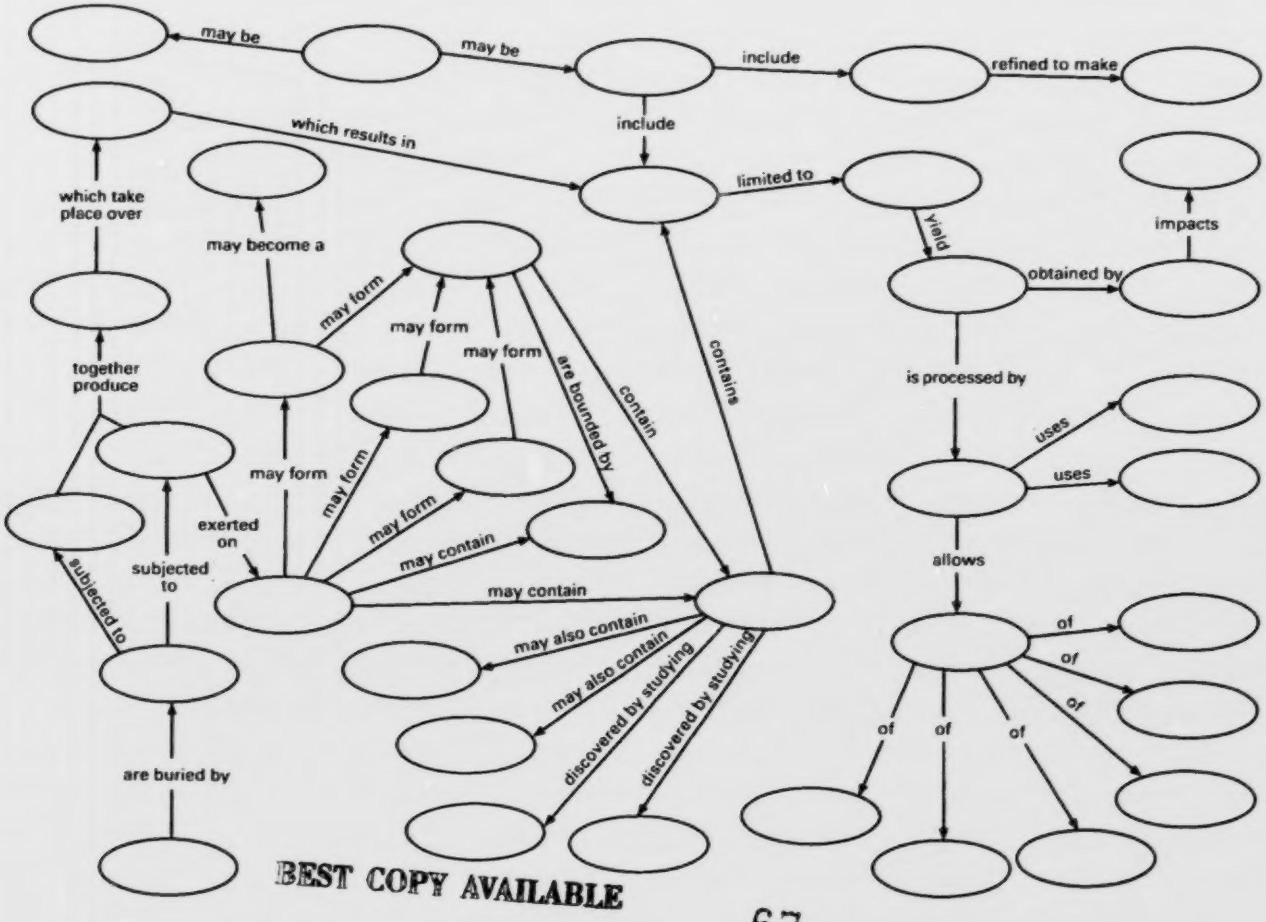
Name: ______________________ Date: __________

Earth Resources Concept Map for Section 1

Fill in the circles on the concept map using the key terms listed below. Each term shown on the list will be used once.

KEY TERMS

- acquisition
- aluminum
- anticlines
- asphalt
- bauxite
- chemical changes
- condensation
- core samples
- crude oil
- crude oil reserves
- diesel fuel
- differing boiling points
- Earth resources
- environment
- extraction
- fault
- fractional distillation
- fuel oil
- gas
- gasoline
- heat
- impermeable rock
- joints
- light gases
- millions of years
- motor oil
- nonrenewable resources
- petroleum
- plankton
- pressure
- renewable resources
- reservoir rock
- sediments
- seismology
- strata (beds)
- synclines
- traps
- water


may be
may be
include
refined to make
which results in
include
limited to
yield
impacts
obtained by
which take place over
may become a
may form
may form
may form
are bounded by
contain
contains
together produce
is processed by
uses
uses
may form
may form
may form
exerted on
subjected to
subjected to
may contain
may contain
allows
may also contain
may also contain
discovered by studying
discovered by studying
of
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of
of
of
are buried by

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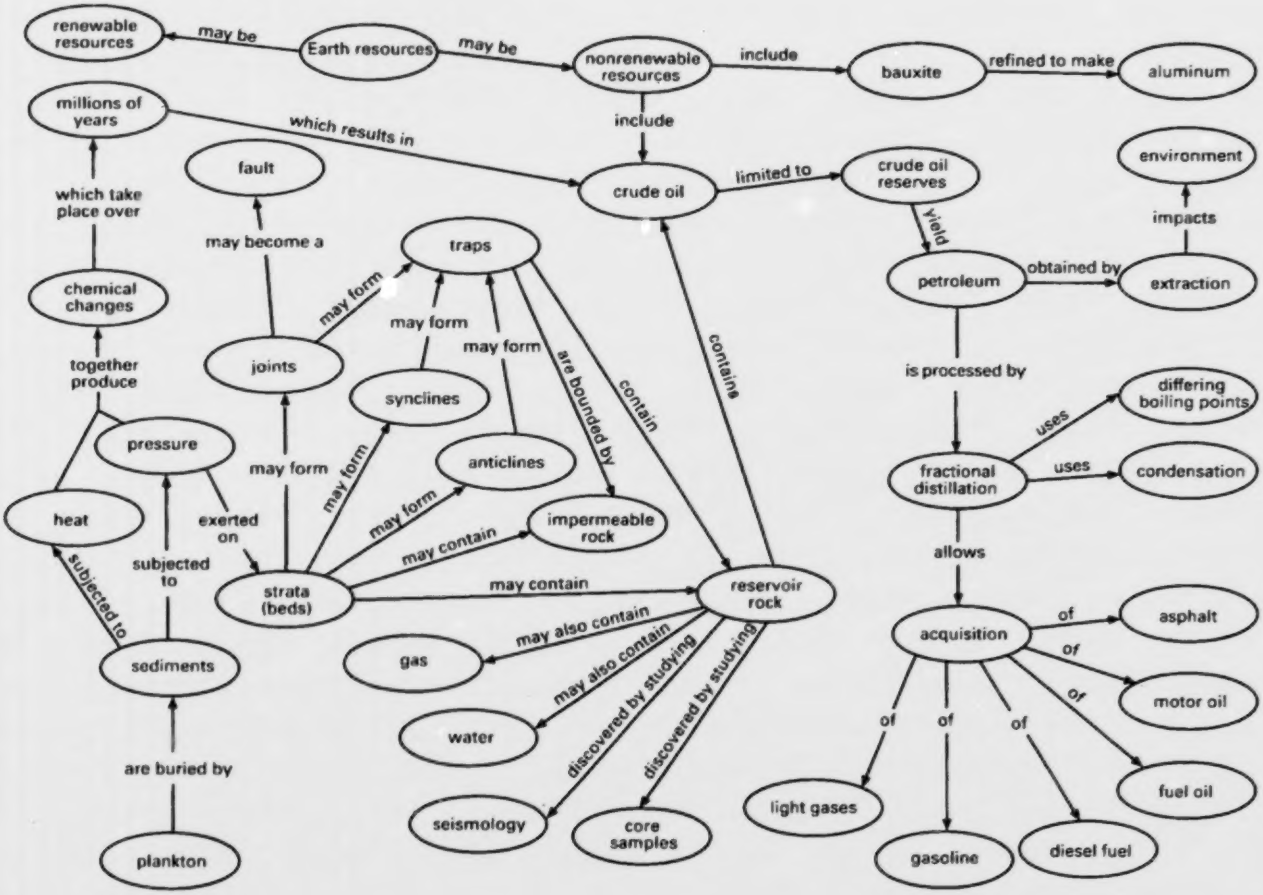
Earth Resources Concept Map for Section 1


renewable resources
may be
Earth resources
may be
nonrenewable resources
include
bauxite
refined to make
aluminum
millions of years
which results in
include
crude oil
limited to
crude oil reserves
environment
fault
yield
impacts
which take place over
may become a
traps
petroleum
obtained by
extraction
chemical changes
may form
may form
may form
contains
joints
synclines
are bounded by
contain
is processed by
together produce
differing boiling points
uses
pressure
anticlines
may form
may form
uses
fractional distillation
condensation
heat
exerted on
may form
impermeable rock
may contain
subjected to
subjected to
may contain
strata (beds)
reservoir rock
allows
may also contain
acquisition
of
asphalt
sediments
gas
may also contain
of
discovered by studying
discovered by studying
of
motor oil
water
of
of
of
are buried by
fuel oil
seismology
core samples
light gases
gasoline
diesel fuel
plankton

SECTION 1:

Earth Resources Project — Student Case Study

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interactions of matter and energy.

LESSON CONCEPT

All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.

SECTION 1:
Locating, Acquiring, and Processing Our Earth's Resources

Section Concepts

Human: Natural resources are used by human populations in order to maintain and improve their existence.

Scientific: The Earth's natural resources are formed over time. These resources have observable physical and chemical properties.

LESSON OVERVIEW

Students select an Earth resource, other than oil, on which to conduct research for their own case study. After each section, students spend a class session researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

After Section 1, students research the following:

- Description of the Earth resource (renewable or nonrenewable)
- Description of the source and location of the raw Earth material
- Method and impact of exploration for the material
- Method and impact of acquisition of the material
- Method and impact of refinement/processing of the material as a human resource

DESIRED OUTCOMES

Students will:

Identify questions and concepts about an Earth resource.

Design and *conduct research* on an Earth resource.

Formulate, revise, and *synthesize* the newly gained information.

Recognize and *analyze* alternate explanations and models about an Earth resource.

Begin creating a presentation about an Earth resource.

Students will use the following scientific thinking processes:

Observing, communicating, comparing, ordering, categorizing, relating, inferring, and applying.

STEPS FOR TEACHING

Teacher Action	Student Action	Suggested Time
Ask students to review the stages of the Earth Resources Chart.	*Examining Prior Ideas*	5 min.
Direct students to brainstorm what they know and want to know about their chosen resource.	*Inferring, Applying, and Relating Information*	5 min.
Guide students in the appropriate research methods and emphasis for their chosen resource.	*Relating Information*	5 min.
Provide time and resources for students to conduct research.	*Applying Knowledge*	50 min.

BACKGROUND FOR TEACHERS

The *National Science Education Standards* emphasize that students should experience science as inquiry which engages them in the active construction of ideas and explanations. Teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich the understanding of science.

Students should be guided to generate questions that make it possible "to analyze data, develop a richer knowledge base, reason using science concepts, make connections between evidence and explanations, and recognize alternative explanations. Ideas should be examined and discussed in class so that other students can benefit from the feedback." Teachers of science can use the ideas of students in their class, ideas from other classes, and ideas from texts, databases, or other sources.

Reference:
National Research Council, *National Science Education Standards*. National Academy Press, Washington, D.C., 1996.

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

KEY WORDS

CASE STUDY
Collected information about an individual, group, or object for use in sociological, medical, environmental, scientific, or psychiatric studies.

SUSTAINABLE
Able to preserve the functioning of existing systems in such a way that resources are not depleted or permanently damaged.

GETTING READY

☐ Obtain materials (see *"What You Will Need")*.

☐ For e student, photocopy:

- *"Activity Page—Earth Resources Project — Student Case Study"*

(for Section 1)

☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).

☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.

☐ Take out the overhead transparencies, *"Earth Resources Chart"* and *"Earth Resources Chart — Section 1."*

TEACHER NOTES

In this lesson, students will apply, to another resource, the pattern of the stages in the Earth Resources Chart. Any Earth material can be used; for example: iron, aluminum, copper, gold, silver, magnesium, tungsten, wood, water, natural gas, coal, and other petroleum products.

Gather as many reference materials as possible. Some possible resources include:

- *Energy Skill Builders* and *Energy 90s*, Enterprise for Education, 1316 Third St., Ste. 103, Santa Monica, CA 90401; (310) 394-9864
- *Guidebook for Federal Resources for K-12 Mathematics & Science*, Eisenhower National Clearinghouse, 1-800-621-5785, editor@enc.org

- *Ground Water Education for Secondary Students*, Water Education Foundation, 717 K St., Ste. 517, Sacramento, CA 95814; (916) 444-6240, <www.water-ed.org>

At the conclusion of each section of the curriculum, provide at least one class session for students to research in class. However, students should also work independently, revisiting their case study as the unit proceeds.

At the end of the entire unit, students will use their research to develop a presentation on their case study. Lesson 18 will provide students an opportunity to present their finished projects.

Before assigning the project to students, it is a good idea to decide what types of end product are acceptable (i.e., essay, poster, oral speech with essay, video). It is also recommended that you set a limit on the number of students that are allowed to complete each type of end product, or else all students might produce the same type of product. In assessing the project, consider not only the quality of presentation, but whether each stage of the Earth Resources Chart was given adequate treatment.

If time permits, you may require students to make an oral presentation. This provides an added dimension to the project: Students become "teachers," and the student listeners can learn more content and increase their presentation skills by watching their peers.

The guidelines for oral presentations are as follows:

- Length should be no longer than 5 minutes.
- Visual props should be included, such as charts, pictures, tables, overheads, or posters.
- Creative expression should be encouraged, such as a dramatization, skit, song, comedy routine, or video.
- The criteria for assessment should include how well the audience understands the stages. (The easiest way to gauge audience understanding is for the listening student audience to draw, sketch, and label the stages of the particular resource being presented.)

Students often have difficulty planning ahead and pacing their work. Therefore, it is a good idea to set up "checkpoint" dates by which students must complete various stages of research.

ACTION NARRATIVE

Prethink

15 minutes

Let's review the Earth Resources Chart to determine what we have learned about oil thus far.

- ▶ Display one or both of the overhead transparencies, *"Earth Resources Chart"* and/or *"Earth Resources Chart* — Section 1."

Ask a student to review and explain each column of the chart, or do it yourself.

Consider the Earth resource you chose for your case study in Lesson 1. Brainstorm what you know and what you want to know about your Earth resource. Ask a few students to share their brainstorms.

- ▶ Distribute *"Activity Page — Earth Resources Project – Student Case Study (Section 1)."*

Today, each of you will begin to research the answers to your questions about the Earth resource you have chosen. Discuss all elements of the Activity Page with the students. The Activity Page is designed to enable students to access their prior knowledge about the section as well as to focus what they want to know about their chosen resources. The sheet also includes additional questions for the students to research.

In your discussion, emphasize to students that their research should include technical and scientific information, such as chemical formulas, equations, scientific studies, cost analyses, and energy use. The content of their research should address all of the stages shown in the Earth Resources Chart and should include illustrations, charts, graphs, diagrams, and other visuals, depending on the scope of preparation that you, as the teacher, would like to emphasize. The length of the research will vary depending on the resource.

Be sure to remind students that at the end of the entire unit they will use their research to develop a product that will be used as a vehicle to present their study. Explain the types of end product that are acceptable to you. Tell students that their projects will be evaluated for quality of presentation and for adequate treatment of each of the stages in the Earth Resources Chart. If you decide to have students give an oral presentation, review the guidelines for oral presentations.

Student Action

45 minutes

Provide the resources and time necessary for students to begin researching information. Assist, guide, and facilitate as necessary.

Action Processing

5 minutes

Who will share one interesting or surprising fact or idea you learned today? Allow a few students to share after each day of research.

At this point, you should have a good start on your research. Continue working outside of class and at home to complete your research on this section. Be sure to see me if you need any help. Remind students that they should be compiling information for their case study in preparation for their culminating report and presentation.

Home Study

Students should continue their ongoing research during the next section. Periodically remind students of this and ask them to share a bit of what they have learned.

CHECKING FOR UNDERSTANDING

Student Reflections

- I discovered that...
- I was interested/surprised to learn that...

Teacher Reflections

- Can students find the necessary information for each stage of the Earth Resources Chart?
- Do the students realize that each Earth resource follows the pattern of the Earth Resources Chart?

EXTENSION

Use this research opportunity to collaborate and integrate with the students' English class. The use of research tools such as source cards and note cards, outlines, and rough drafts is taught in English courses; their use can enhance this scientific case study.

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Name: ______________________ Date: __________

Earth Resources Project – Student Case Study (Section 1)

Select an Earth material (rock, mineral, or plant) that humans use as a resource. Conduct research to develop your own case study on this Earth resource. Use the categories from the Section 1 portion of the Earth Resources Chart to focus your research. Consider the impact of exploration, processing, and use on the Earth's environment; the scientific technologies needed; and the supply of, and demand for, the resource.

PREPARATION

What do you know about the Earth resource that you chose? How is it found and processed?	What do you want to know about the Earth resource that you chose? How is it found and processed?

Additional Research Questions

Purpose

- Why is the resource used by humans?
- For what purpose(s) is the resource used?

Description

- **What physical and chemical properties make the resource desirable for use?**

Exploration

- What is the source and location of the raw Earth material?
- How do humans obtain the raw material from the earth?
- What is the impact of exploration, both positive and negative?

Processing

- Once the raw material is obtained, how is it processed for use?
- What are the impacts of processing the resource, both positive and negative?

Earth Resources Project – Student Case Study (Continued)

GUIDELINES FOR RESEARCH

1. First, read general information about the resource.
2. Either using separate note cards or separate pieces of paper for each research question, answer each question with notes or with a paraphrase from your research.
3. Always use your own words. Take notes on key ideas, not entire sentences.
4. Consult a minimum of three resources to obtain complete information about the resource.
5. Always credit each source of information (book, pamphlet, magazine, encyclopedia, expert interview, speech, etc.) with the author, title or name of source, and date.
6. Gather interesting data, graphics, diagrams, and other visuals to enhance your research.

GUIDELINES FOR PRESENTATION

Format Possibilities

- Written report
- Poster
- Brochure
- Booklet
- Video
- Oral presentation
- Display
- Other ideas

WHAT HAVE YOU LEARNED?

After completing the case study, you will use your research to develop a presentation that will be evaluated using the following standards:

Content

- Addresses all stages in the Earth Resource Chart.
- Answers all research questions.
- Includes technical and scientific information, such as chemical formulas, equations, scientific studies, cost analyses, and energy use when applicable.

Quality of Work

- Includes illustrations, charts, graphs, diagrams, and other visuals.
- Uses standard language, including spelling, punctuation, and capitalization.
- Is printed in ink or typed.
- Is organized in such a way that it shows clear understanding and careful thought.
- Is inviting, neat, and eye-appealing.
- Is creative and unique.

Oral Presentation

- Is no longer than 5 minutes.
- Is clearly spoken, using visuals, props, or models.
- Demonstrates enthusiasm and uses eye contact.
- Is spoken, not read.

Be sure to check with your teacher for any particular requirements you may have for this class.

Notes

sample lesson

BEST COPY AVAILABLE

Getting Crude Oil: *Oil Extraction*

Lesson Concept

Physical and chemical properties facilitate human extraction of natural resources.

Lesson Overview

Students discuss issues surrounding the acquisition of natural resources. Students explore the difficulties of crude oil extraction. Students simulate crude oil extraction.

SECTION 1:

Locating, Acquiring, and Processing Our Earth's Resources

Section Concepts

Human: Natural resources are used by human populations in order to maintain and improve their existence.

Scientific: The Earth's natural resources are formed over time. These resources have observable physical and chemical properties.

Desired Outcomes

Students will:

Demonstrate how Earth resources are acquired. Students will build and manipulate a model for extracting oil.

Identify economic and environmental issues related to the acquisition of Earth resources. Students will describe the economic and environmental issues related to oil extraction.

Students will use the following scientific thinking processes:

Observing, communicating, comparing, relating, inferring, and applying.

STEPS FOR TEACHING

Teacher Action	Student Action	Suggested Time
Ask students to identify how Earth resources, such as oil, are acquired.	*Examining Prior Ideas*	10 min.
Direct students to construct and use an apparatus to separate oil from an oil-pebble mixture.	*Observing, Recording, and Processing Information*	55 min.
Direct students in designing their own process for extracting oil.	*Posing a Challenge*	
Guide students in comparing the effectiveness of extraction processes.	*Processing Information*	10 min.
Instruct students to reflect on oil extraction methods.	*Reflection*	10 min.

BACKGROUND FOR TEACHERS

The deposits of oil which are relatively close to the surface and easy to remove have already been discovered and are being extracted. Some oil deposits no longer contain commercial quantities of oil or gas and have been abandoned. Both older oil fields and new fields located in geographically challenging areas present ever-increasing difficulties to companies involved in the extraction of oil from the Earth. Since oil wells must be drilled more deeply, extraction procedures must be modified to improve their efficiency as well as to minimize the impact on the environment. In addition, horizontal wells are being used more frequently.

For oil reservoirs located below the surface of the ocean floor, oil extraction can pose an even greater challenge. Before building an offshore oil platform, oil companies drill exploratory holes to assess the extent of the oil trap. It is only when the value of the volume of oil present exceeds the high costs of acquiring the oil that oil companies decide to construct a drilling platform. Usually, only about 10 percent of the exploration wells result in a commercially viable drilling operation.

One common method of drilling an oil well involves sending a drill string with a revolving drill bit down a steel pipe. This pipe is partially enclosed in a casing that keeps the walls of the oil well from caving in. As the well is deepened, other casings may be inserted into the well to protect the hole that has already been drilled and to help control any high pressures encountered during drilling. A lubricating fluid, called *mud*, is pumped through the drill pipe and is spread by jets in the drill bit itself. The mud floats away rock and metal debris that result from the drilling while also cooling and lubricating the drill bit, thereby promoting its life. The mud, composed primarily of clay particles, water, and lubricating chemicals, must be of sufficient weight to prevent oil from erupting into the well shaft. The pressure caused by the weight of the mud in the well must be carefully controlled. When the mud is not heavy enough, and there is not sufficient pressure, the oil can erupt into the well shaft. This eruption, called a *blowout*, is highly dangerous to the drilling crew as well as potentially devastating to the environment surrounding the well.

Engineers involved in oil extraction try to calculate the ease with which oil will flow from the reservoir rock into the well pipe. When reservoir rock has good porosity (storage) but poor permeability (ability of the fluid to flow), pumps can be placed at the surface to exert pressure and cause the formation to fracture. Material such as sand can then be placed into the artificial fracture to keep it open, thus allowing oil to be produced.

Oil companies are researching various methods to extract the maximum amount of oil from traps Sometimes they decide to use secondary methods to increase the amount of oil that can be extracted. For example, they might pump water or steam down an adjoining well, causing the oil to float higher in the reservoir. Steam also helps the oil to move more easily and increases the amount of recoverable oil in the reservoir rock. Pumping water into an adjacent well also prevents the land surface from sinking. Sinking, or subsidence, is a result of reduced under-

KEY WORDS

Acquisition
The removal of a substance from a mixture of substances.

Environment
The air, land, and water area around the oil well.

Extraction
The removal of crude oil from the Earth.

Petroleum
Crude oil, or oil that has been taken out of the ground.

ground volume, caused by removing the oil. Another method of oil extraction involves the injection of a gas into an adjoining well to re-pressurize the well and force the oil to the pump. A method that has been tried but abandoned involved the injection of a biodegradable acid into an adjoining well, which breaks down the reservoir rock and allows the oil to flow more readily into the well.

Even using these secondary methods of extraction, only 30 percent of the crude oil can actually be removed due to the tendency of oil to cling to the surrounding rock.

Reference:

Petroleum Exploration: A Continuing Need. American Petroleum Institute, Washington, D.C.

WHAT YOU WILL NEED

For the class:

- Pictures of oil wells

For each group of students:

- Newspaper
- Ring and ring stand
- Cold water
- 1 clear plastic bottle with pump nozzle (such as a hand soap bottle) and plastic tubing that extends into the bottle
- 1 piece of tubing, 30-40 cm long, to fit the delivery end of the plunger
- 1 100-mL graduated cylinder
- 1 funnel
- 50 to 100 mL cooking oil
- 50 to 100 mL small, clean pebbles (to cover the oil)
- 2 sheets of graph paper
- Exploration materials (i.e., distractors) such as hot water, liquid soap, saw dust, etc. (see "Teacher Notes")
- Cheesecloth (see "Teacher Notes")
- Rubber bands (see "Teacher Notes")

GETTING READY

☐ Obtain materials (see *"What You Will Need"*).

☐ For each student, photocopy:

- ***"Student Investigation — Simulating Oil Extraction"***

☐ Photocopy each of the following onto a transparency:

- ***"Overhead — Oil Derrick"***
- ***"Overhead — Oil Well"***

☐ Assign students to groups of two.

☐ Determine the amount of oil and water to be added to the pumper in Parts 1 and 2 of the investigation. The amount will vary depending on the size of the pumper and depth of the pump.

☐ Determine spill or cleanup procedures for accidents at the lab stations.

☐ *Take out the overhead transparencies,* "Earth Resources Chart" and "Earth Resources Chart — Section 1"

TEACHER NOTES

Depending on the ability level of the class, be prepared to demonstrate how to put the equipment together and how to use it.

The placement of several waste oil containers around the room will reduce the amount of potential spillage and provide more time for actual lab work.

Encourage students to adopt a rhythmic pumping procedure.

If possible, have several spare plungers available.

Glass graduated cylinders are easier to clean than plastic.

If small grains of sand/gravel are used, the pumper may clog. A piece of cheesecloth held in place over the end of the pumper with a rubber band will help prevent clogging. Rubber bands from orthodontic braces work well for this purpose.

As you set up, be sure that the plastic tubing does not touch the bottom of the plastic bottle.

Part 2 of the investigation simulates the water injection of adjacent wells. The length of the plastic tubing inside the plastic bottle is critical for this part of this investigation. As students pour water into the plastic bottle, it is important to make sure that the water level stays below the bottom of the plastic tubing.

For the student-designed investigation (Part 3), you will need to gather various materials that could be used by the students. You will want to provide not only the materials that you think the students will need, but also distractors which will help students to "think outside of the box." Distractors might include a hot plate, an air pump, liquid dish soap, other types of oil, saw dust, and dirt.

You might have the students design the investigation on one day and perform it on the next. If time permits, you could have the student perform more then one investigation. The more the students explore, the better they will understand the research processes of oil companies.

As you will note, there is no specific Home Study page. The analysis questions or the student-designed activity might be used as a Home Study. What you assign depends on how you approach the lab.

Supplemental classroom resources recommended for this lesson:

All About Petroleum. American Petroleum Institute, Washington, D.C.

Running on Oil. National Science Teachers Association, Washington, D.C., 1995.

ACTION NARRATIVE

Prethink

10 minutes

Based on what you learned in the last Student Investigation, what are the characteristics of places that would be the best locations to drill for oil?
Students might suggest looking for folds, faults, or other places where oil can be trapped in the Earth.

Let's consider how we obtain some of our Earth resources.
Ask students to discuss how different resources are obtained. Examples might include trees that are harvested for lumber, crude oil that is extracted from the Earth, and bauxite ore (used to make aluminum) that is mined from the Earth.

What types of issues are involved in acquiring Earth resources?
Focus on the actual methods and the issues: geography (difficulty in locating the resource); scarcity of the resource; the energy use required; damage to the environment; cost; and any scientific principles (i.e., density) involved in acquiring resources from their natural locations.

How would you predict that we could get crude oil out of the Earth?
Students might suggest sucking or pumping it out of the Earth.

Record student responses for later review in Action Processing.

Problem for Student Investigation

Let's investigate how to extract crude oil from the Earth and what possible problems the oil companies face in extracting all of the crude oil.

▶ Distribute "Student Investigation — Simulating Oil Extraction."

Student Action

55 minutes

See "Student Investigation — Simulating Oil Extraction."

Action Processing

20 minutes

What methods worked the best for extracting oil? Why?
Student answers will vary.

What effect did the water have on the oil?
Be sure to explain the concept of density.

How does an oil well work?

▶ Display "Overhead — Oil Derrick," "Overhead — Oil Well," and any available pictures of oil wells.

Discuss how the well works. Be sure to discuss how and why companies might inject water into an adjacent well.

What types of issues might an oil company face if they choose to inject substances into the wells to increase production?
An oil company must consider the extra costs and the uncertainty over whether the technique will retrieve more oil.

What will be the impact on the groundwater and the ecosystem?
Students might say that a leak will contaminate the groundwater.

If you were to inherit land that has oil wells on it, which method(s) of extraction would you select, and why?
The method(s) they choose may vary. Be sure students understand the reasons for choosing a particular method.

Now let's review your previous thoughts about how oil is processed into a form we can use. Were they accurate? Should your original response be edited or changed? If so, how would you modify it and why?
Allow students an opportunity to share their ideas and record their responses.

Now, let's refer to our Earth Resources Chart.

▶ Display the overhead transparency, "*Earth Resources Chart — Section 1*".

Encourage students to refer to their Earth Resources Chart.

Now, let's add to our Earth Resources Chart for oil.

Accept student suggestions. The following sample chart shows possible responses.

Sample Portion of Earth Resources Chart: Oil

Method of Exploration	Impacts of Exploration		Method of Acquisition	Impacts of Acquisition	
	+	–		+	–
Seismographic	Separates oil	Creating seismic disturbance in locating oil	Pumping	Create jobs	Can change natural habitats
			Transporting	Creates jobs	Possible leaks or spills

CHECKING FOR UNDERSTANDING

Student Reflections

- How have my ideas about the extraction of crude oil changed?
- Extraction is…
- The most efficient method of obtaining an Earth resource may not be the best way because…
- Extracting oil has an effect on…

Teacher Reflections

- How have students' perceptions about the extraction of crude oil changed?
- Do students understand that oil is trapped between particles of the substrate and must be extracted from that location?
- Do students understand the extraction processes for oil?
- Do students understand the issues encountered during the acquisition of Earth resources?

EXTENSIONS

Have students contact an oil company or use the Internet to investigate the newer methods of extracting oil.

Have students investigate the different careers involved in an offshore drilling operation, such as the planner/economist, environmental/civil engineer, drilling engineer, logging/reservoir engineer, and extraction mud engineer. (See Appendix A.)

Oil Derrick

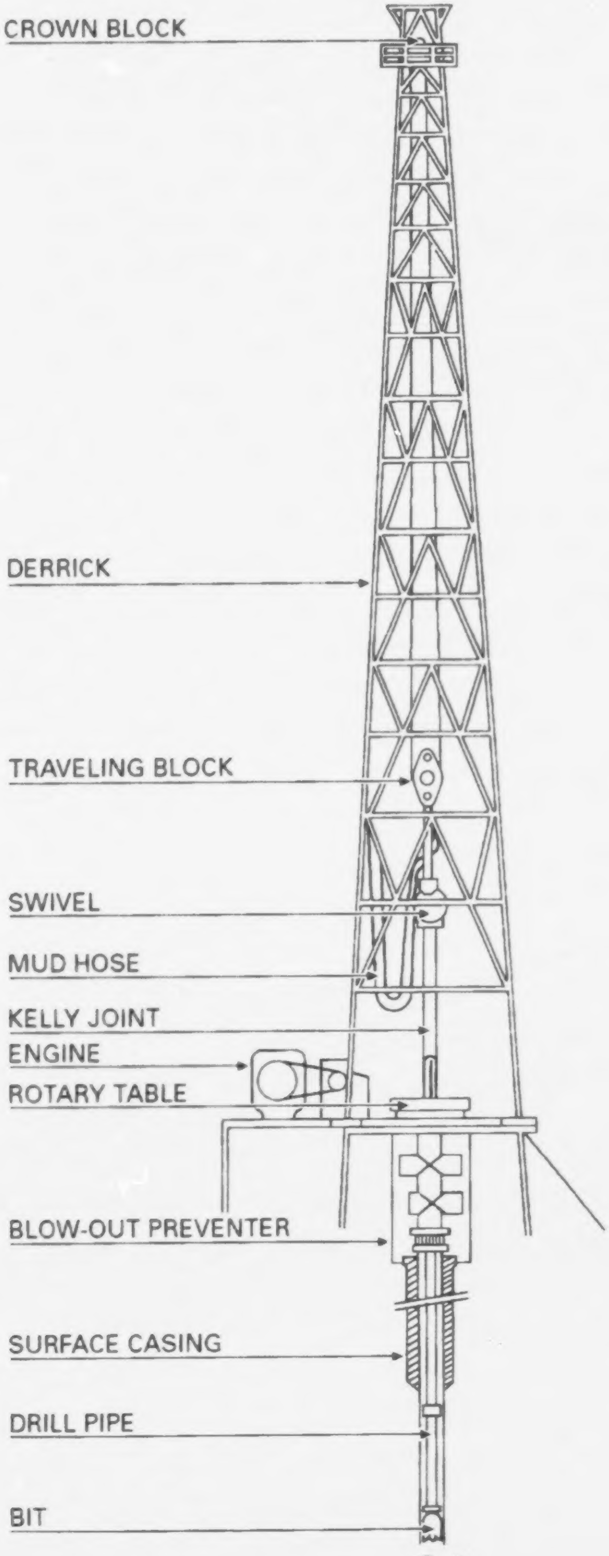

CROWN BLOCK
DERRICK
TRAVELING BLOCK
SWIVEL
MUD HOSE
KELLY JOINT
ENGINE
ROTARY TABLE
BLOW-OUT PREVENTER
SURFACE CASING
DRILL PIPE
BIT

Figure courtesy of American Petroleum Institute

Oil Well

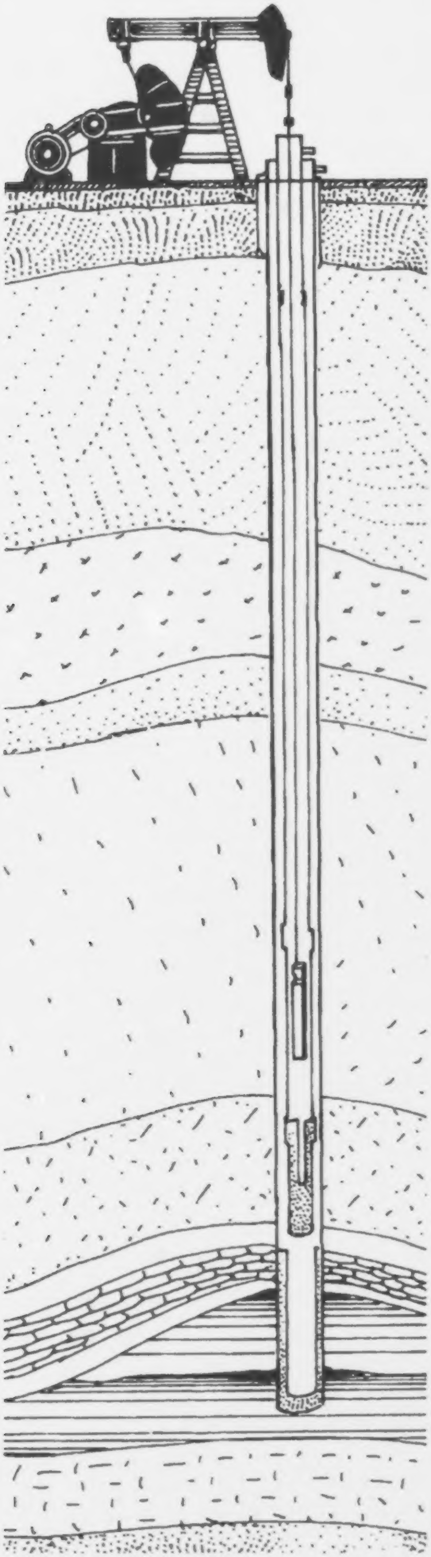


Figure courtesy of the National Energy Foundation

Name: ____________________ Date: __________

Simulating Oil Extraction

PREPARATION

☐ **Read**

As a first step, read the entire investigation carefully.

☐ **Background**

Prepare your background to this investigation.

☐ **Problem for Student Investigation**

1. What methods are used to extract oil?
2. Why can't the oil companies extract all of the oil from a deposit?

☐ **Prediction/Hypothesis**

Write a hypothesis to the problem statements above.

Note: You will also be asked to make predictions during the lab.

INVESTIGATION

☐ **Materials**

Clear plastic bottle with a pump nozzle, funnel, 30-40 cm of plastic tubing, 100-mL graduated cylinder,
50-100 mL of cooking oil, 50-100 mL of water, small pebbles, graph paper

☐ **Procedure**

Assemble your simulated oil well as shown in the diagram.

Create a system of data collection, such as a table or chart, that will efficiently contain your data.

☐ **Part 1: Oil-and-Pebble Method**

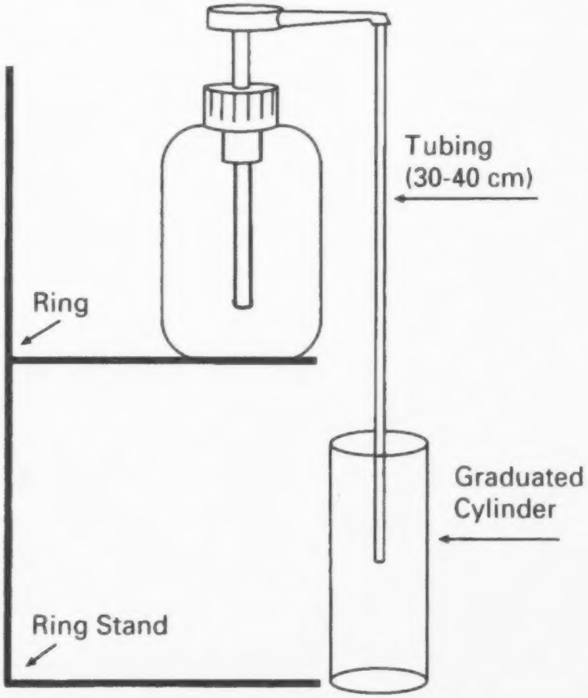
1. Fill your simulated oil well (plastic pumper bottle) to about half with pebbles. Measure an amount of oil that will cover the pebbles. Record the amount. Be sure the tube of the pumper is below the rock level.

   How much of the oil will you be able to remove?

2. Pump the plunger until no more oil can be removed from the well. Measure the extracted oil and record the amount in your data chart. Observe the pebbles and record your observations.

   What prevented all of the oil from being removed? Explain.

"The Pumper"



Stimulating Oil Extraction (Continued)

☐ Part 2: Cold-Water Method

Oil companies need to remove as much of the deposits of oil as possible. How might a company succeed in this task? Oil companies have tried many methods, but have determined that if they use the effects of density differences, they will have more success. To use this method, they inject water into the adjacent well to aid in the recovery process.

How will density differences affect the removal of the remaining oil?

1. Place 50 mL of water into the simulated oil well (plastic pumper bottle). Let the mixture settle for about 3 minutes. Observe the mixture. Record your observations.
2. Again pump the pumper until you have removed as much of the oil as possible. Measure the extracted oil and record this measurement in the data chart. Observe the pebbles and record your observations.

What prevented all of the oil from being removed? Explain.

☐ Part 3: Student Exploration

Oil companies have conducted research for many years to determine other methods to recover the remaining oil left in the ground. Imagine that you have been hired by an oil company to research different methods to accomplish this task. Given the materials your teacher has gathered, determine another method that the oil company might use to extract more oil.

You will need to follow the method outlined in the beginning of this activity to design your investigation. Determine your materials list and procedure for the investigation. Do not forget to develop your problem statement and hypothesis.

Remember, data collection is very important to the investigative process. Your procedure must be detailed enough so that any scientist could follow your steps and replicate your experiment.

Note: You must return to the well the amount of oil removed in the cold-water extraction to determine the effectiveness of the various methods.

☐ Data

Add the volume of oil removed using the oil-and-pebble method (Part 1) to the volume of oil removed with the cold-water method (Part 2). The total is the volume of oil that would have been extracted by the cold-water method alone. Record this amount into your table as the "Total Volume of Oil Extracted" by the cold-water method.

EXTRACTION TABLE

Condition of Investigation Pumping	Volume Before	Volume Pumped	Total Volume of Oil Extracted	% of Oil Pumped
Oil and Pebbles				
Cold Water				
Student Design				
Other Student Design				

Stimulating Oil Extraction (Continued)

Observations

Part 1

Part 2

Part 3

☐ Results

Summarize your data from all three parts of the investigation and any patterns that emerge.

☐ Analysis

1. Construct a bar graph to compare the different methods of extraction. Be sure to include the results from your student-designed activity.

2. Compare your student-designed activity results with those of other students in the class. If their results are different from yours, add their results to your bar graph.

3. Reviewing the results of all tests, rank the methods used in terms of their effectiveness and plot their relative effectiveness on the line graph below.

Least effective — Most effective

Stimulating Oil Extraction (Continued)

4. Explain why each of the methods was more or less effective.

5. How are the methods and devices you used similar to those used in actual oil-drilling operations?

6. What problems might each method cause for the oil company owner and how might these methods impact the environment around the well site? List your ideas in the following table.

EXTRACTION TABLE		
Method of Extraction	Possible Difficulty / Expense	Potential Environmental Problem(s)
Oil and Pebbles (Part 1)		
Adding Cold Water (Part 2)		
Student Design (Part 3)		

7. Would any of these methods leave the oil unusable? If so, explain what the problem would be and how you might make the oil useful again.

☐ **Conclusion**

1. Reviewing your hypothesis in the various parts of the investigation, determine whether your predictions were proven to be correct. Why or why not?

2. When oil is being formed, a gas is also formed, causing the oil deposit to be under a great amount of pressure. When the oil deposit is first tapped, the gas causes the oil to rush up the extraction pipe and gush out of the top. The oil company must cap the well, or the oil will be lost. Oil companies have tried to increase their yield of oil by injecting a gas into a well that is adjacent to the oil-producing well. What do you think might be an advantage to this method?

Simulating Oil Extraction

PREPARATION

☐ **Read**

As a first step, read the entire investigation carefully.

☐ **Background**

Prepare your background to this investigation.

☐ **Problem for Student Investigation**

1. What methods are used to extract oil?
2. Why can't the oil companies extract all of the oil from a deposit?

☐ **Prediction/Hypothesis**

Write a hypothesis to the problem statements above.

Note: You will also be asked to make predictions during the lab.

INVESTIGATION

☐ **Materials**

Clear plastic bottle with a pump nozzle, funnel, 30-40 cm of plastic tubing, 100-mL graduated cylinder,
50-100 mL of cooking oil, 50-100 mL of water, small pebbles, graph paper

☐ **Procedure**

Assemble your simulated oil well as shown in the diagram.

Create a system of data collection, such as a table or chart, that will efficiently contain your data.

☐ **Part 1: Oil-and-Pebble Method**

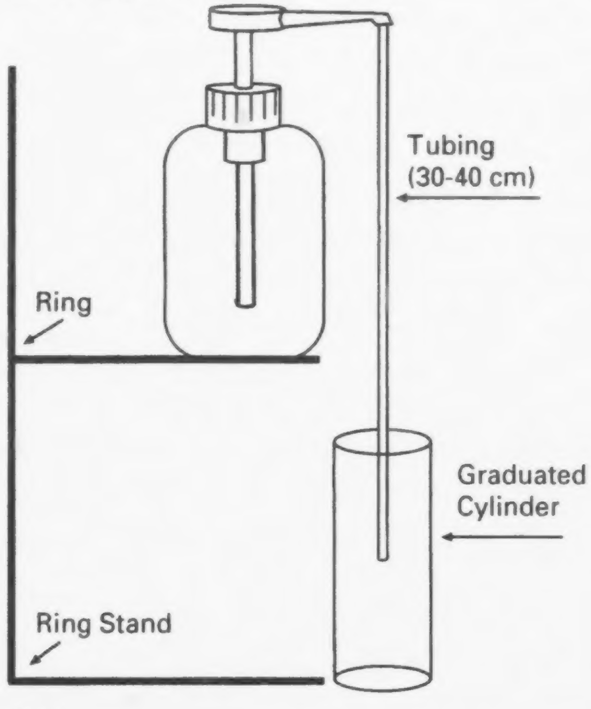
1. Fill your simulated oil well (plastic pumper bottle) to about half with pebbles. Measure an amount of oil that will cover the pebbles. Record the amount. Be sure the tube of the pumper is below the rock level.

How much of the oil will you be able to remove?

2. Pump the plunger until no more oil can be removed from the well. Measure the extracted oil and record the amount in your data chart. Observe the pebbles and record your observations.

What prevented all of the oil from being removed? Explain.

"The Pumper"



☐ Part 2: Cold-Water Method

Oil companies need to remove as much of the deposits of oil as possible. How might a company succeed in this task? Oil companies have tried many methods, but have determined that if they use the effects of density differences, they will have more success. To use this method, they inject water into the adjacent well to aid in the recovery process.

How will density differences affect the removal of the remaining oil?

1. Place 50 mL of water into the simulated oil well (plastic pumper bottle). Let the mixture settle for about 3 minutes. Observe the mixture. Record your observations.

2. Again pump the pumper until you have removed as much of the oil as possible. Measure the extracted oil and record this measurement in the data chart. Observe the pebbles and record your observations.

What prevented all of the oil from being removed? Explain.

☐ Part 3: Student Exploration

Oil companies have conducted research for many years to determine other methods to recover the remaining oil left in the ground. Imagine that you have been hired by an oil company to research different methods to accomplish this task. Given the materials your teacher has gathered, determine another method that the oil company might use to extract more oil.

You will need to follow the method outlined in the beginning of this activity to design your investigation. Determine your materials list and procedure for the investigation. Do not forget to develop your problem statement and hypothesis.

Remember, data collection is very important to the investigative process. Your procedure must be detailed enough so that any scientist could follow your steps and replicate your experiment.

Note: You must return to the well the amount of oil removed in the cold-water extraction to determine the effectiveness of the various methods.

☐ Data

Add the volume of oil removed using the oil-and-pebble method (Part 1) to the volume of oil removed with the cold-water method (Part 2). The total is the volume of oil that would have been extracted by the cold-water method alone. Record this amount into your table as the "Total Volume of Oil Extracted" by the cold-water method.

EXTRACTION TABLE

Condition of Investigation	Volume Before Pumping	Volume Pumped	Total Volume of Oil Extracted	% of Oil Pumped
Oil and Pebbles	50 to 100 ml	25-50 ml		25 to 50%
Cold Water50 to 100 ml	50-75 ml	50-75 ml		50 to 75%
Student Design	Answers vary	Answers vary		Answers vary
Other Student Design	Answers vary	Answers vary		Answers vary

Observations

Part 1 *Answers will vary.*

The oil appears to stick to the pebbles; not all of the oil can be removed.

Part 2 *Answers will vary.*

The oil floats to the top of the water, enabling more of the oil to be pumped out.

Part 3 *Answers will vary.*

☐ Results

Summarize your data from all three parts of the investigation and any patterns that emerge.

☐ Analysis

1. Construct a bar graph to compare the different methods of extraction. Be sure to include the results from your student-designed activity.

   Answers will vary.

2. Compare your student-designed activity results with those of other students in the class. If their results are different from yours, add their results to your bar graph.

   Answers will vary.

3. Reviewing the results of all tests, rank the methods used in terms of their effectiveness and plot their relative effectiveness on the line graph below.

   Answers will vary.

   Least effective Part 1 Part 2 Most effective

4. Explain why each of the methods was more or less effective.

   Answers will vary. Between Part 1 and Part 2, the oil stuck to the pebbles, and the length of the pump pipe was a limiting factor. The water helped to raise the oil level for better extraction.

5. How are the methods and devices you used similar to those used in actual oil-drilling operations?

   Answers will vary.

6. What problems might each method cause for the oil company owner and how might these methods impact the environment around the well site? List your ideas in the following table.

EXTRACTION TABLE

Method of Extraction	Possible Difficulty / Expense	Potential Environmental Problem(s)
Oil and Pebbles (Part 1)	*Not all of the deposit can be extracted.*	*Possible spills/leaks; changes in the environment.*
Cold Water (Part 2)	*Expense of the water; contamination of the oil.*	*Changes in the underground environment; organism endangerment.*
Student Design (Part 3)	*Answers will vary.*	*Answers will vary.*

7. Would any of these methods leave the oil unusable? If so, explain what the problem would be and how you might make the oil useful again.

Answers will vary.

☐ Conclusion

1. Reviewing your hypothesis in the various parts of the investigation, determine whether your predictions were proven to be correct. Why or why not?

Answers will vary.

2. When oil is being formed, a gas is also formed, causing the oil deposit to be under a great amount of pressure. When the oil deposit is first tapped, the gas causes the oil to rush up the extraction pipe and gush out of the top. The oil company must cap the well, or the oil will be lost. Oil companies have tried to increase their yield of oil by injecting a gas into a well that is adjacent to the oil-producing well. What do you think might be an advantage to this method?

Answers will vary.

Section at a Glance: *Section 2*

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interaction of matter and energy.

SECTION 2 OVERVIEW

The second section explores the use of the resource by consumers.

SECTION 2

Using Our Earth's Resources

Section Concepts

Human: Human use of the Earth's natural resources is based upon chemical and physical properties.

Scientific: All matter has observable chemical and physical properties which govern its interactions.

LESSON OVERVIEWS

Lesson 6

Slipping and Sliding With Oil: *The Lubricating Properties of Oil*

Students discuss the varied uses of petrochemical products. Students investigate some properties of petrochemical products: in particular, the physical properties of lubricating oils.

Lesson 7

Oil Goes to Work: *Lubricating Oil in the Engine*

Students identify the parts of an engine and investigate how lubricating oil is used in an engine to prevent friction. Students explore the path taken by oil to lubricate the parts of an engine.

Lesson 8

Oil, the Pickup Artist: *The Cleaning Function of Lubricating Oil*

Students observe the cleaning properties of lubricating oil and learn how oil changes affect engine performance and efficiency.

Lesson 9

Oil's Coworkers: *Oil Additives*

Students perform several experiments to understand how additives enhance the properties of lubricating oil and improve its performance in the engine.

Lesson 10

Oil Keeps Clean and Changes: *The Role of Oil Filters in the Engine*

Students investigate the differences between new and used oil and the action of filters in an engine.

Earth Resources Project — Student Case Study

Students have already selected an Earth resource, other than oil, on which to conduct research for their own case study. After completing Section 2, students spend another day researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	**Lesson Concept**	**Scientific Thinking Processes**	**Desired Outcomes** *Students will…*
LESSON 6. **Slipping and Sliding With Oil:** *The Lubricating Properties of Oil*	The physical and chemical properties of matter determine how it interacts with other matter.	• Observing • Ordering • Categorizing • Relating • Inferring • Applying	*Observe, determine,* and *record* that all matter has properties. Students will *identify* the general physical properties of lubricating oil. *Discuss* physical properties of substances that make them useful to humans. Students will *observe* the physical properties of lubricating oil and *discuss* their effects on a car's engine.
LESSON 7. **Oil Goes to Work:** *Lubricating Oil in the Engine*	Physical properties of matter determine its ability to interact effectively with other pieces of matter	• Observing • Communicating • Relating • Inferring • Applying	*Demonstrate* that an Earth resource is used in a specific manner. Students will *trace* the path that oil follows through an engine. *Discuss* how the physical and chemical properties of a resource material determine its value for humans. Students will *discuss* how the properties of oil make it a good substance for keeping an engine running smoothly. *Understand* that complicated machines contain several parts connected in various ways. Students will *describe* in basic terms how oil lubricates a V-8 engine.
LESSON 8. **Oil, the Pickup Artist:** *The Cleaning Function of Lubricating Oil*	Substances in a mixture interact based upon their chemical and physical properties.	• Communicating • Observing • Comparing • Inferring • Applying	*Discuss* that when a chemical change occurs, new substances are produced with a release of some form of energy. Students will *describe* the products and *energy* release of the chemical reaction when gasoline is burned. *Explore* the interaction of matter. Students will *describe* the interactions of water and oil with carbon and metal particles when forming mixtures. *Identify* that objects behave in many different ways depending, in part, on their surroundings. Students will *explain* how metallic and carbon contaminants suspended in lubricating oil interfere with the proper functioning of an engine. *Explain* that only one variable at a time can be changed during a fair comparison test of the effectiveness of a substance. Students will *design* an experiment, using only one variable at a time, to test the cleaning function of oil.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	**Lesson Concept**	**Scientific Thinking Processes**	**Desired Outcomes** *Students will…*
LESSON 9. **Oil's Coworkers:** *Oil Additives*	The physical and chemical properties of the individual substances of a mixture determine how the mixture will interact with other substances.	• Observing • Communicating • Comparing • Relating • Inferring • Applying	*Describe* how environmental factors can physically and chemically change substances. Students will *discuss* the physical and chemical changes that oil undergoes during use. *Discuss* how properties of a substance can be altered by mixing it with a small amount of other substances. Students will *describe* the benefits of additives in lubricating oil.
LESSON 10. **Oil Keeps Clean and Changes:** *The Role of Oil Filters in the Engine*	Mixtures can be separated by use of physical properties.	• Observing • Communicating • Comparing • Ordering • Cataloging • Relating • Applying	*Explain* that when matter interacts with other matter under ordinary circumstances, it changes in various ways. Students will *compare* new and used oil samples. *Discuss* how mixtures can be separated by filtering for particle size. Students will *experiment* with the use of different materials to filter oil.
Earth Resources Project — *Student Case Study (Research Day)*	All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.	• Observing • Communicating • Comparing • Ordering • Categorizing • Relating • Inferring • Applying	*Identify* questions and concepts about an Earth resource. *Design* and *conduct research* on an Earth resource. *Formulate*, *revise*, and *synthesize* the newly gained information. *Recognize* and *analyze* alternate explanations and models about an Earth resource. *Continue creating* a presentation about an Earth resource.

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Getting Ready For Section 2

Lesson 6
Slipping and Sliding With Oil: *The Lubricating Properties of Oil*

WHAT YOU WILL NEED

For the class:

- 5 to 6 samples of rusted metal

For each group of students:

- 1 Newton spring scale
- 3 syringes labeled "Control (C)," "Water (W)," and "Oil (O)"
- Small container of tap water labeled "Water"
- Small container of vegetable oil labeled "Oil"

For each student, to conduct** "Home Study — A Trusty Tale" **(optional):

- Steel wool or fine sand paper
- 6 nongalvanized iron nails
- 3 plastic lids or petri dishes
- Sample of clean vegetable oil

Lesson 7
Oil Goes to Work: *Lubricating Oil in the Engine*

WHAT YOU WILL NEED

For the class:

- Bottle of hand lotion
- Piece of heat-warped metal
- Bimetallic strip
- Bunsen burner
- Transparent engine model that can be cranked so that the parts move (optional)
- Transparent tape (optional)
- Erasable marker (optional)

Getting Ready

☐ Photocopy *"Activity Page — The Lubricating System"* onto a transparency (cut into strips to make labels for each engine part that is lubricated with oil).

☐ Photocopy *"Activity Page — Oil Drops"* (cut apart the "Recycle Used Oil" symbols and use to illustrate the flow of oil through the engine).

Lesson 8
Oil, the Pickup Artist: *The Cleaning Function of Lubricating Oil*

WHAT YOU WILL NEED

For the class:

- Balance scales (if possible, one for each group)
- Candle
- Matches
- Glass plate or slide

For each group of students:

- 2 small, narrow bottles or large test tubes with lids or stoppers
- 25-50 mL water
- 25-50 mL vegetable oil
- 1 graduated cylinder
- 0.5 g ground charcoal
- 0.5 g iron filings
- Soap, water, and paper towels for cleanup

Getting Ready

☐ Grind charcoal briquettes into a fine powder.

Lesson 9
Oil's Coworkers: *Oil Additives*

WHAT YOU WILL NEED

For the class:

- 3 or 4 different samples of one-quart motor oil containers from different manufacturers
- 1 c vegetable oil
- 3 viscosity tubes (see *"Getting Ready"*)
- 1 150-mL beaker
- Ice
- Water
- Hot plate
- 20 mL 0.1 M hydrochloric acid
- 10 shiny magnesium strips, each 10 cm in length
- Steel wool
- Blender
- Vegetable shortening
- 2 stop watches or a clock with a second hand
- Pieces of grime-coated metal (see *"Getting Ready"*)
- Pieces of "clean" metal for comparison
- Chart paper and markers or overhead transparency and pens

(continued)

(continued from previous page)

For each group of students:

TEST 1

- Water
- Graduated cylinder
- 3 test tubes and labels
- 3 stoppers that fit the test tubes
- Detergent in dropper bottle
- 5 mL Substance A (a defoamer used for carpet cleaning)
- 5 mL Substance B (saturated solution of baking soda) (see *"Getting Ready"*)
- Test tube rack

TEST 2

- Water
- Quality detergent in a dropper bottle or soapless hand cleaner
- 2 small jars with lids, such as baby food jars
- 2 labels for the jars
- Dirty oil or grease sample (see *"Getting Ready"*)

TEST 3

- Water
- 20 mL vinegar
- Graduated cylinder
- Balance
- 4 150-mL beakers
- 10 mL Substance B (saturated solution of baking soda) (see *"Getting Ready"*)
- Waste container
- 3 pieces of zinc

Getting Ready

☐ Collect three or four different one-quart motor oil containers from different manufacturers, including SAE weights of 30, 10/40, and 5/30.

☐ For the viscosity demonstration, prepare a warm water bath and an ice bath.

☐ Prepare viscosity tubes using three screw-cap test tubes (or three 18 x 100 test tubes with stoppers) and 3 BBs. Fill each test tube almost completely with vegetable oil. Place one BB in each test tube and then cap or stopper the test tubes. It is desirable to have no air bubble in the closed tube.

☐ Display simulated pieces of "clean" and "dirty" engine parts on a table before class begins. To simulate dirty engine parts, mix vegetable shortening with dirt and dust, and then coat a piece of metal with the "grime." If you prefer a real sample, ask a bicycle shop to donate the rear gear cluster from an old bike. (This is road grime at its best.)

☐ Mix a saturated solution of 4.2 g baking soda and 500 mL of water to make Substance B.

☐ Prepare 20 mL of a 0.1 M hydrochloric acid solution.

☐ Shine each of the 10 magnesium strips by rubbing them with steel wool.

Lesson 10

Oil Keeps Clean and Changes: *The Role of Oil Filters in the Engine*

WHAT YOU WILL NEED

For the class:

- Samples of new and simulated used oil (see *"Getting Ready"*)
- Oil filter cut in half lengthwise
- One or more transparent fuel filter(s)
- Variety of car owner manuals

For each group of students:

- Coffee filter paper
- Paper towels, toilet paper, facial tissue
- Cheesecloth
- Pieces of cotton or polyester fabric
- Any other filtering material that is readily available
- Clear plastic beverage water bottles (one small, and one medium or large so that the smaller one will fit inside the other)
- Nail
- 100 mL simulated used oil (see *"Getting Ready"*)
- Graduated cylinder

Getting Ready

☐ For each group of students, prepare simulated used oil using the following substances:
  - 100 mL vegetable oil
  - 1 g sand or dirt
  - 1.25 g charcoal
  - 1 g metal pieces (if available)

☐ Cut an oil filter in half, lengthwise.

Earth Resources Project — Student Case Study (Research Day)

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

Getting Ready

☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).

☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.

Storyline

One way to attract students' attention to the properties of lubricating oil and to get them involved in the curriculum is to use the following storyline. Choose four students to perform the short "play" in front of the class. Provide time for them to learn their roles prior to the performance.

ANALYSIS OF A RESOURCE: PART 2

As the Oil Moves Through

Characters: Mom, Elias, Cecylia, and the narrator

Narrator: Mom is changing the oil on the car.

Elias: Mom, how long is that going to take for you to change the oil? You've been working on it for a long time, it seems.

Mom: It doesn't take long, but our trip through the redwoods put a lot of miles on our car. The car's users manual says the oil needs to be changed every few thousand miles, and I'm changing the oil filter, too. It needs to be changed each time we change the oil, so a clean filter can keep the new oil clean for a longer time. You know, that reminds me: the accident that we came across on our trip involved a diesel fuel spill. The oil in our car comes from the same crude oil refining process that produces diesel fuel.

Elias: But Mom, you and Dad said that *gasoline* comes from the refining of crude oil!

Mom: That's right. Diesel fuel, gasoline, and motor oil also come from the same refining process. There are also many other products. It seems that crude oil is essential to our way of life.

Narrator: Cecylia joins Mom and Elias.

Cecylia: Mom, you promised that you would show me how to change the oil some day. How about making today the day you show me? I'll be driving soon, and I'll need to know about cars.

Mom: That sounds like a great idea, Cecylia. Come help me change the oil and filter in our car.

Cecylia: It's very hard to see why it is important to put oil in the engine, Mom. Where does it actually go?

Mom: Cecylia, it is hard to see where the oil goes because most of the engine parts that require oil are covered. (Mom turns excitedly to Cecylia.) Cecylia, let's go to the model store and buy a model engine! Then I can really show you where all the oil goes throughout the engine and why it's necessary. Without oil, the engine simply won't run. The friction is too great.

Cecylia: Great idea, Mom!

Narrator: Later that day, Cecylia is busy with her model engine.

Cecylia: Mom, I see why you need oil on the crankshaft and the pistons. They simply don't turn or move up and down without something to make it slippery. But Mom, if the oil goes through the engine and filter, it still gets dirty. Where or how does the dirt and grime get into the oil?

Mom: Yes, the oil gets *very* dirty, and then it can't work as well as clean oil. So, we change the oil and the oil filter periodically because we don't want dirty oil moving through the engine. Why don't we look at what the oil does in the engine and how it gets dirty?

Suggested Strategies for Assessment

Section 2

PETRO MAIL

To use this assessment activity, you can engage your students in one of three ways:

- Ask students to generate questions to quiz other students on the individual lesson concepts or on section concepts.
- Use one of the writing prompts provided in the Checking for Understanding section found at the end of each lesson to review other students' conceptual understanding.
- Generate specific questions or writing prompts to assess students' knowledge of a specific concept in the lesson or section which you stressed.

Additional information on "PETRO Mail" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LEARNING JOURNALS

Using the writing prompts and questions found in the Checking for Understanding section, or using other prompts you have generated, have the students write continuously for 5 to 10 minutes.

Additional information on "Learning Journals" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LIVE-AT-FIVE INTERVIEWS

Have students interview a mechanic or car owner, using the following sample questions:

- What is the purpose of oil in the engine?
- What function do additives serve in oil?
- What is the purpose of the oil filter and how does it work?
- How does oil become used?
- Why do car manufacturers state that motor oil must be changed?
- What does dirty oil do to the performance of the engine?

Additional information on "Live-at-Five Interviews" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CREATIVE EXPRESSION

To use this assessment activity, you can have students implement one of the following short-term or long-term projects:

Short-Term

- Create a poster with examples of various petrochemical products and their use.
- Create a poster illustrating how oil helps to lubricate moving parts.
- Design a skit showing how and what particles are picked up by oil as it travels through the engine.
- Design a flipbook to show the path of oil in the engine.

Long-Term

- Create a commercial advertising various petrochemical products.
- Create a cartoon illustrating the path of motor oil and how it helps the engine. Be sure to list all additives.
- Create a rap that discusses the path of motor oil and how oil additives help to protect the engine.
- Create a skit to illustrate how oil becomes used.

Additional information on "Creative Expression" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

GROUP EVALUATION POSTER SESSION OR WHITE BOARD

This activity can help you gauge students' preconceptions before each lesson begins, or during the Prethink portion of each lesson. Save the poster for review at the end of the lesson. If you do this activity on white boards, have the students record the ideas in their learning journals. You should refrain from adding information or correcting the students' statements. While students review their prior thinking during the Action Processing section of each lesson, you may want to ask questions to enable the students to dispel the misconceptions shown on the posters.

Sample prompts include:

- Explain the function of oil in the engine.
- Explain the function and types of oil additives.
- What physical properties of oil change as oil becomes used?
- How does the oil filter work in removing particles from the oil as it moves through the engine?

Additional information on "Group Evaluation Poster Session or White Board" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

PORTFOLIOS

If you are using this assessment activity, students should take the following steps at this time:

- Make their second selections.
- Self-reflect as to why they chose the entry.
- Revise their thoughts about their topics.
- Describe what they have learned about the chosen subject.
- Decide what they still want to know.

Additional information on "Portfolios" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CONCEPT MAPS

To use this assessment activity, try one of the following ideas:

- Have students generate a list of high-frequency or key terms used in the day's activities or lessons, and then have them use this list to construct a concept map.
- Generate a list of key terms which you have determined to assess the students' conceptual understanding of the lesson, and then have students generate a concept map that includes these key terms.
- Use the following concept map to assess your students' conceptual understanding of the section. Provide your students with copies of *"Activity Page — Earth Resources Concept Map for Section 2."* Have your students fill in the blank concept map, using the list of key terms used. You may wish to fill in a few of the key terms to get students started. Use the corresponding Teacher Page to assess students' understanding.

Additional information on "Concept Maps" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

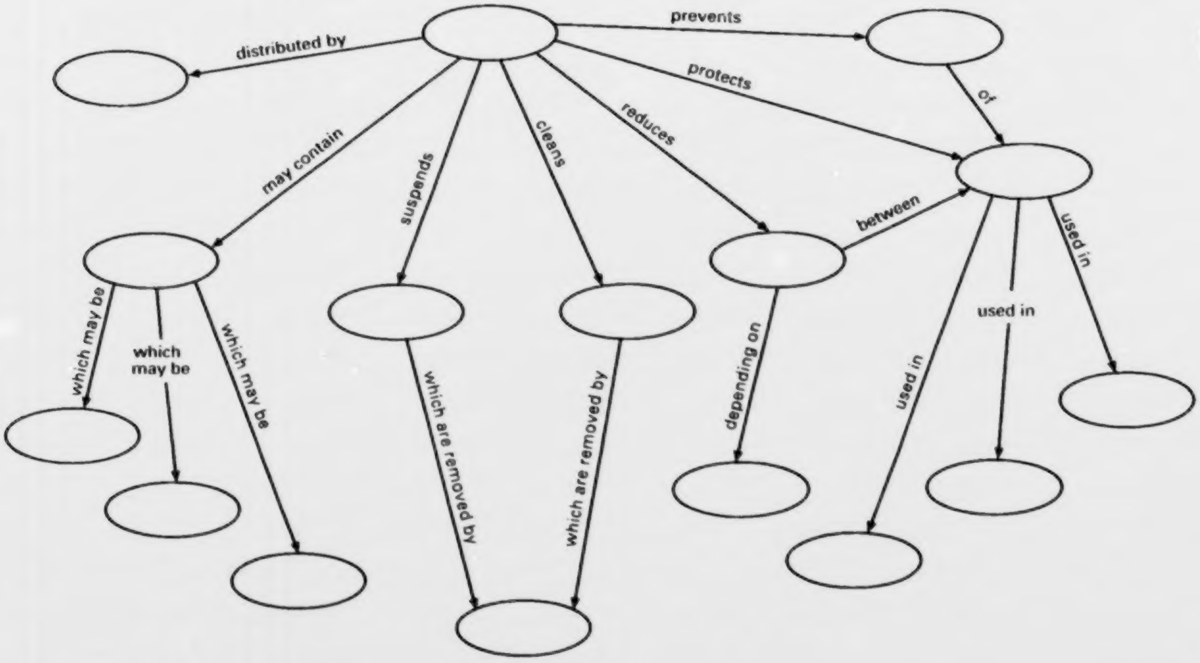
Name: ______________________ Date: __________

Earth Resources Concept Map for Section 2

Fill in the circles on the concept map using the key terms listed below. Each term shown on the list will be used once.

KEY TERMS

- additives
- anti-corrosives
- combustion products
- corrosion (rusting)
- cylinders
- detergents
- foam inhibitors
- friction
- lubricating oil
- metals
- oil filter
- oil pump
- particles
- pistons
- shaft bearings
- viscosity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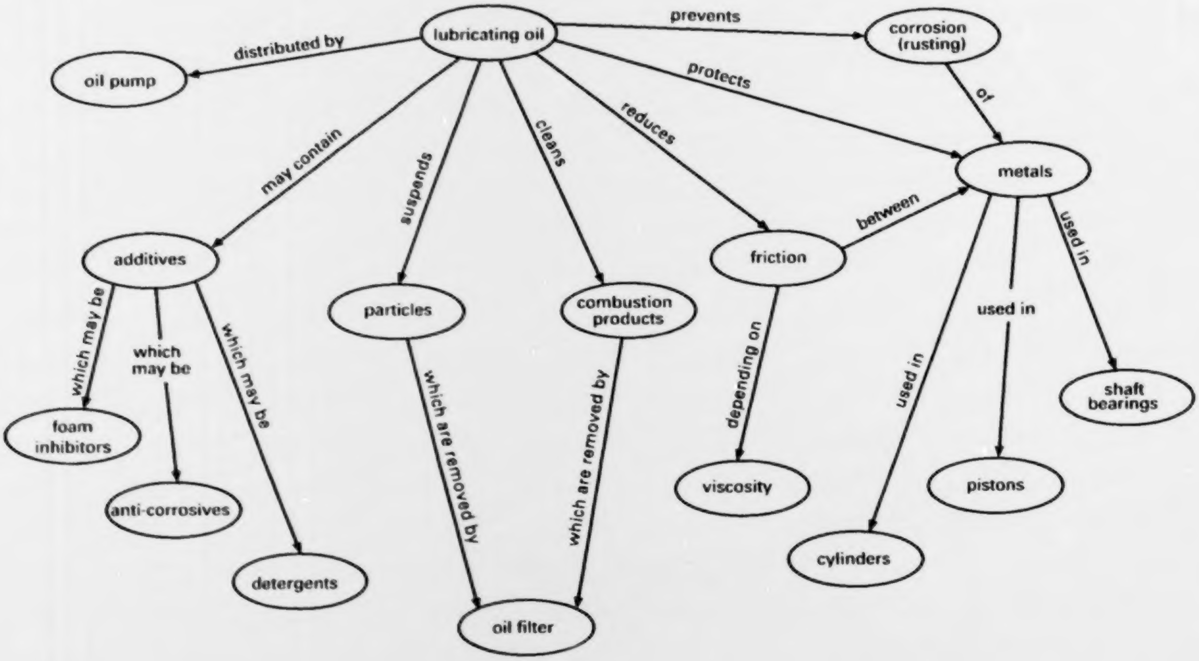
Earth Resources Concept Map for Section 2


lubricating oil
prevents
corrosion (rusting)
distributed by
oil pump
protects
of
may contain
suspends
cleans
reduces
metals
between
used in
additives
friction
particles
combustion products
used in
which may be
which may be
which may be
which are removed by
which are removed by
depending on
used in
shaft bearings
foam inhibitors
anti-corrosives
detergents
viscosity
pistons
cylinders
oil filter

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SECTION 2:
Earth Resources Project — Student Case Study

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interactions of matter and energy.

LESSON CONCEPT

All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.

SECTION 2: [illegible]

Using Our Earth's Resources

Section Concepts

Human: Human use of the Earth's natural resources is based upon chemical and physical properties.

Scientific: All matter has observable chemical and physical properties which govern its interactions.

LESSON OVERVIEW

Students have already selected an Earth resource, other than oil, on which to conduct research for their own case study. After completing Section 2, students spend another day researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

After Section 2, students research the following:

- The properties of the resource that meet human needs
- Specific uses of the resource
- Ways in which the resource changes during use
- Impact of its use on the environment

DESIRED OUTCOMES

Students will:

Identify questions and concepts about an Earth resource.
Design and *conduct research* on an Earth resource.
Formulate, revise, and *synthesize* the newly gained information.
Recognize and *analyze* alternate explanations and models about an Earth resource.
Continue creating a presentation about an Earth resource.

Students will use the following scientific thinking processes:

Observing, communicating, comparing, ordering, categorizing, relating, inferring, and applying.

STEPS FOR TEACHING

Teacher Action	Student Action	Suggested Time
Ask students to review the stages of the Earth Resources Chart.	*Examining Prior Ideas*	5 min.
Direct students to brainstorm what they know and want to know about their chosen resource.	*Inferring, Applying, and Relating Information*	5 min.
Guide students in the appropriate research methods and emphasis for their chosen resource.	*Relating Information*	5 min.
Provide time and resources for students to conduct research.	*Applying Knowledge*	50 min.

BACKGROUND FOR TEACHERS

The *National Science Education Standards* emphasize that students should experience science as inquiry which engages them in the active construction of ideas and explanations. Teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich the understanding of science.

Students should be guided to generate questions that make it possible "to analyze data, develop a richer knowledge base, reason using science concepts, make connections between evidence and explanations, and recognize alternative explanations. Ideas should be examined and discussed in class so that other students can benefit from the feedback." Teachers of science can use the ideas of students in their class, ideas from other classes, and ideas from texts, databases, or other sources.

Reference:
National Research Council, *National Science Education Standards.* National Academy Press, Washington, D.C., 1996.

GETTING READY

☐ Obtain materials (see *"What You Will Need")*.

☐ For each student, photocopy:

- *"Activity Page — Earth Resources Project – Student Case Study" (for Section 2)*

☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).

☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.

☐ Take out the overhead transparencies, *"Earth Resources Chart"* and *"Earth Resources Chart — Section 2."*

TEACHER NOTES

In this lesson, students continue applying the pattern of the stages of resource use to another resource.

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

Gather as many reference materials as possible. Some possible resources include:

- *Energy Skill Builders* and *Energy 90s*, Enterprise for Education, 1316 Third St., Ste. 103, Santa Monica, CA 90401; (310) 394-9864
- *Guidebook for Federal Resources for K-12 Mathematics & Science*, Eisenhower National Clearinghouse, 1-800-621-5785, editor@enc.org
- *Ground Water Education for Secondary Students*, Water Education Foundation, 717 K St., Ste. 517, Sacramento, CA 95814; (916) 444-6240, <www.water-ed.org>

At the conclusion of each section of the curriculum, provide at least one class session for students to research in class. However, students should also work independently, revisiting their case study as the unit proceeds.

Students often have difficulty planning ahead and pacing their work. Therefore, it is a good idea to set up "checkpoint" dates by which students must complete various stages of research.

KEY WORDS

CASE STUDY
Collected information about an individual, group, or object for use in sociological, medical, environmental, scientific, or psychiatric studies.

SUSTAINABLE
Able to preserve the functioning of existing systems in such a way that resources are not depleted or permanently damaged.

ACTION NARRATIVE

Prethink

15 minutes

Let's review the Earth Resources Chart to determine what we have learned about oil thus far.

▶ Display one or both of the overhead transparencies, "Earth Resources Chart" and/or "*Earth Resources Chart — Section 2.*"

Ask a student to review and explain each column of the chart, or do it yourself.

Consider the Earth resource you chose for your case study in Lesson 1. Brainstorm what you know and what you want to know about your Earth resource.
Ask a few students to share their brainstorms.

▶ Distribute *"Activity Page — Earth Resources Project – Student Case Study (Section 2)."*

Today, each of you will continue to research your questions about the Earth resource you have chosen, as well as the answers to questions on the Activity Page.
Discuss all elements of the Activity Page with students. Be sure to remind students that at the end of the entire unit they will use their research to develop a product that will be used as a vehicle to present their study. Lesson 18 will provide students an opportunity to present their finished projects.

Review the types of end product that are acceptable to you. Remind students that their projects will be evaluated for quality of presentation and for adequate treatment of each of the stages in the Earth Resources Chart. If you decide to have students give an oral presentation, review the guidelines for oral presentations.

Student Action

45 minutes

Provide the resources and time necessary for students to begin researching information. Assist, guide, and facilitate as necessary.

Action Processing

5 minutes

Who will share one interesting or surprising fact or idea you learned today?
Allow a few students to share after each day of research.

Be sure to continue working outside of class and at home to complete your research on this section. See me if you need any help.
Remind students that they should be compiling information for their case study in preparation for their culminating report and presentation.

Home Study

Students should continue their ongoing research during the next section. Periodically remind students of this and ask them to share a bit of what they have learned.

CHECKING FOR UNDERSTANDING

Student Reflections

- I discovered that…
- I was interested/surprised to learn that…

Teacher Reflections

- Can students find the necessary information for each stage of the Earth Resources Chart?
- Do the students realize that each Earth resource follows the pattern of the Earth Resources Chart?

EXTENSION

Use this research opportunity to collaborate and integrate with the students' English class. The use of research tools such as source cards and note cards, outlines, and rough drafts is taught in English courses; their use can enhance this scientific case study.

Name: ______________________ Date: __________

Earth Resources Project – Student Case Study (Section 2)

Continue to conduct research as you develop your own case study. Centering on the Earth resource you chose, focus on the ways in which humans use the resource. Use the categories from the Section 2 portion of the Earth Resources Chart to focus your research. Consider the impact of exploration, processing, and use on the Earth's environment; the scientific technologies needed; and the supply of, and demand for, the resource.

PREPARATION

What do you know about the use of the Earth resource that you chose?	What do you want to know about the use of the Earth resource that you chose?

Additional Research Questions

Use of the Earth Resource

- What are the specific uses of the resource?
- What specific properties of the resource meet human needs?
- How is the resource modified or improved for use?
- How does the resource change during use?
- What is the impact of its use on the environment, both positive and negative?

Notes

Section at a Glance: *Section 3*

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interaction of matter and energy.

SECTION 3 OVERVIEW

The third section discusses the routes of used oil disposal into the environment and the related impacts.

SECTION 3:
Disposing of Our Earth's Resources

Section Concepts

Human: Materials from human societies affect both physical and chemical cycles of the Earth.

Scientific: Because ecosystems are interdependent, a change in one system may have far-reaching effects on the others.

LESSON OVERVIEWS

Lesson 11

What to Do With Used Oil? *Surface Water*

Students investigate the advantages and disadvantages of a common, but hazardous and illegal, method of used motor oil disposal. Students determine that disposing of used oil in waterways contaminates the water and can impact plants and wildlife.

Lesson 12

What to Do With Used Oil? *The Backyard*

Students investigate the advantages and disadvantages of a common, yet hazardous and illegal, method of used motor oil disposal. Students analyze the environmental impact of dumping oil in the backyard. Students determine that a contaminant dumped into a model of a backyard leaches into the groundwater system.

Lesson 13

What to Do With Used Oil? *The Trash Can*

Students investigate the advantages and disadvantages of a common, yet hazardous and illegal, method of used motor oil disposal. Students analyze the environmental impact of discarding used motor oil in a landfill. Students determine how used motor oil travels through a model of a landfill.

Lesson 14

Why Should We Care About Used Oil? *How Used Oil Can Affect the Environment*

Students investigate the following concepts: *food pyramids, trophic levels,* and *biological magnification*. Students analyze the effects of a small amount of toxin on a food pyramid.

Earth Resources Project — Student Case Study

Students have already selected an Earth resource, other than oil, on which to conduct research for their own case study. After completing Section 3, students spend another day researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	**Lesson Concept**	**Scientific Thinking Processes**	**Desired Outcomes** *Students will…*
LESSON 11. **What to Do With Used Oil?** *Surface Water*	A change in one part of the ecosystem has consequences for other parts of the ecosystem.	• Observing • Communicating • Comparing • Relating • Inferring • Applying	*Explain* the impact on the environment when a used natural resource is discarded in waterways. Students will *analyze* the impact on the environment when used oil and its contaminant substances are discarded in waterways. *Generalize* that although substances are useful, they may be hazardous if not properly controlled. Students will *explain* why diluting oil to parts per million is not an effective method for disposing of used oil in waterways.
LESSON 12. **What to Do With Used Oil?** *The Backyard*	A change in one part of the ecosystem has consequences for other parts of the ecosystem.	• Observing • Communicating • Relating • Inferring • Applying	*Explain* the impact on the environment when a used natural resource is discarded on the ground and eventually reaches the groundwater. Students will *analyze* the environmental impact of used oil and its contaminant substances when they are discarded on the ground and eventually reach the groundwater system. *Generalize* that substances may be hazardous if not properly controlled. Students will *explain* why dumping oil in the backyard is not a safe nor environmentally sound method of used oil disposal.
LESSON 13. **What to Do With Used Oil?** *The Trash Can*	A change in one part of the ecosystem has consequences for other parts of the ecosystem.	• Observing • Communicating • Relating • Inferring • Applying	*Predict* how a single component of a system might interact with other components in various ways. Students will *explain* how used oil, with its contaminant substances, might leach into groundwater through a landfill. *Explain* the environmental impact caused by the disposal of a used natural resource into a landfill. Students will *analyze* the environmental impacts that can occur when used oil and its contaminants are discarded in a landfill. *Generalize* that natural systems have the capacity to reuse water, but the capacity is limited. Students will *evaluate* the basis for California Health and Safety Code 25250.5 and the legal methods of disposal for used oil and its contaminants.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	**Lesson Concept**	**Scientific Thinking Processes**	**Desired Outcomes** *Students will...*
LESSON 14. **Why Should We Care About Used Oil?** *How Used Oil Can Affect the Environment*	Along with energy and nutrients, toxins cycle through the trophic levels of food chains, affecting the dynamic balance within ecosystems.	• Observing • Communicating • Ordering • Cataloging • Relating • Inferring • Applying	*Explain* the feeding relationships of organisms in a food pyramid. Students will *communicate* how organisms in a food pyramid can become exposed to toxic substances in used oil. *Trace* the path of a contaminant through a food pyramid. Students will *investigate* the route by which used oil contaminants can travel through a food pyramid. *Explain* the process of biological magnification. Students will *communicate* the process by which concentrations of heavy metals, such as those found in used motor oil, increase in a food pyramid. *Evaluate* how a change in one population can affect another population. Students will *analyze* how toxic heavy metals, such as those found in used motor oil, can affect the size of populations that were not directly exposed to the toxin.
Earth Resources Project — *Student Case Study (Research Day)*	All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.	• Observing • Communicating • Comparing • Ordering • Categorizing • Relating • Inferring • Applying	*Identify* questions and concepts about an Earth resource. *Design* and *conduct research* on an Earth resource. *Formulate*, *revise*, and *synthesize* the newly gained information. *Recognize* and *analyze* alternate explanations and models about an Earth resource. *Continue creating* a presentation about an Earth resource.

Getting Ready For Section 3

Lesson 11

What to Do With Used Oil? *Surface Water*

WHAT YOU WILL NEED

For each group of students (Part 1):

- Talcum powder
- A small sample of clean, 10W-40 motor oil
- Large, flat, dark-colored basin
- Ruler
- Medicine dropper
- Water

For each group of students (Part 2):

- Distilled water for rinsing and diluting
- 5 small, clear cups (or a reaction plate or well tray)
- Flat toothpicks
- 1-mL plastic pipette or eye dropper
- 2 drops lead nitrate solution
- White paper
- 4 to 5 drops potassium iodide solution
- Food coloring (if lead nitrate method is not used)

Getting Ready

☐ Set up a centralized dispensing area where students will bring a cup (or plate or tray) to receive drops of solutions.

☐ Set up a centralized disposal bucket into which students will rinse the materials from their trays.

☐ There are two possible methods for conducting this part of the investigation: *lead nitrate* or *food coloring*. If the *lead nitrate* method will be used, prepare the following solutions for each class:
- Lead nitrate: Dissolve 16 g in 100 mL of distilled water.
- Potassium iodide: Dissolve 17 g in 100 mL of distilled water.

Lesson 12

What to Do With Used Oil? *The Backyard*

WHAT YOU WILL NEED

For each group of four students:

- Transparent plastic terrarium or clear plastic shoe box
- Large plastic syringe or pump from lotion or liquid hand soap
- Medicine dropper or glass pipette
- Watering can or spray bottle
- Razor blade
- Blue food coloring (1:3 dilution)
- Piece of cheese cloth, 2 cm^2
- Plastic tubing, 4 in. in length
- Water
- 6 large-diameter plastic drinking straws
- Clay
- Rubber band
- Coarse sand

Lesson 13

What to Do With Used Oil? *The Trash Can*

WHAT YOU WILL NEED

For the class:

- Single-edged razor blade or Exacto knife
- Scissors
- Metal skewer
- Bunsen burner or other flame source
- Videotape, *Kids Talkin' Trash*
- Copies of *Beyond 2000: California's Continuing Need for Landfills*

For selected groups:

- Collection of liner materials (i.e., plastic bags, etc.)

For each group of students:

- 2 clean, two-liter plastic bottles with labels removed (or other, similarly sized bottles)
- Gravel
- Sample of typical soil from local area (i.e., from an empty lot or field)
- 2 mL (20 drops) blue food coloring
- Small quantity of garbage such as banana peels, bread, newspaper, plastic, etc.

For extension:

- 4 strips of pH paper (minimum)

Getting Ready

☐ Obtain a TV/videotape player and queue video if necessary.

Lesson 14

Why Should We Care About Used Oil? *How Used Oil Can Affect the Environment*

WHAT YOU WILL NEED

For a class of 30 students:

- 900 2-in. pieces of yarn in a ratio of 2/3 white to 1/3 colored (adjust numbers as needed for class size; 30 pieces/student is recommended)
- 20 paper bags for primary consumers
- 30 strips of fabric for armbands, each about 3 in. wide and 12 in. long, as follows:
  - 20 in fabric color #1
  - 7 in fabric color #2
  - 3 in fabric color #3
- Videotape, *Fish Sticks*
- Pictures of smelt, trout, and humans
- Posters and overhead transparencies of a variety of food chains and food pyramids
- Graph paper

Getting Ready

☐ Cut 900 pieces of yarn to represent plankton (see *"What You Will Need"*).

☐ Find an area for the class to perform the simulation. A classroom can be used if you move the chairs and tables out of the way. Otherwise, a cafeteria, gymnasium floor, or outdoor area may be necessary. Rope or tape off the habitat area.

☐ Prepare strips of colored fabric to serve as arm bands (see *"What You Will Need"*).

☐ Assign a number to each member of each trophic level.

☐ Obtain a videotape player and queue video if necessary.

Earth Resources Project — Student Case Study (Research Day)

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

Getting Ready

☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).

☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.

Storyline

One way to attract students' attention to methods of used oil disposal and their impact on the environment and get them involved in the curriculum is to use the following storyline. Choose three or four students to perform the following skit in front of the class. Provide time for them to learn their roles prior to the performance.

ANALYSIS OF A RESOURCE: PART 3

An Oily Mess

Note: This part of the skit is most effective when performed as an introduction to Lesson 11.

Characters: Narrator, neighbor, Cecylia

Narrator: Cecylia has finished helping her mother change the oil in their car. She sees the next-door neighbor.

Neighbor: Hey, I see you were helping your mother change the oil in your car. That's different for a *girl!*

Cecylia: I enjoy working on the car. My dad doesn't know much about it. Someone needs to know what to do in case the car breaks down on a vacation. Besides, it makes me feel useful. But now I have to decide what to do with this used motor oil.

Neighbor: I don't worry about that used stuff. When I change my oil I get rid of the used oil any way I can.

Cecylia: Any way you can?!? What do you mean by that?

Neighbor: That's just what I mean, any way I can! If I have an empty bottle or container, I pour the used oil into it and throw it in the trash. If I don't have a container, I just pour it out where nobody can see it. If I have some tall weeds, I use it as a weed killer so I don't have to cut them down. Sometimes I have some old brake fluid or antifreeze in a container, and I just pour the used oil into that.

Cecylia (excited): What?!? Don't you realize what could happen if you just pour used oil on the ground? How do you know that the used oil won't end up hurting the environment? Let's investigate to see what could happen.

Neighbor: Well, I never thought about whether it's bad for the environment when I throw away my oil.

Cecylia: Tell you what: I'm going to do a little investigation. Do you want to join me?

Neighbor: Nah. Just tell me what happens.

Note: This part of the skit is most effective when performed as an introduction to Lesson 12.

Characters: Narrator, Cecylia, Elias, and Andrea

Narrator: Cecylia has just completed her experiment. But she still has the used oil that she needs to get rid of. Her brother and sister arrive.

Andrea: Cecylia, what do you have there?

Cecylia: I helped Mom change the oil in the car. I'm not sure what to do with the used oil.

Elias: All my friends say that you can put it in old milk cartons and throw it in the garbage. The sanitation company is paid to take care of these things, so we can give it to them.

Cecylia: Elias, wouldn't that be kind-of like an oil spill?

Elias: Don't be an airhead. It would be enclosed in the milk carton. It just goes into the garbage.

Cecylia (unsure but not knowing what else to think): Well, maybe you're right. But I wonder whether it's safe for the environment? Let's try a little investigation.

Suggested Strategies for Assessment

Section 3

PETRO MAIL

To use this assessment activity, you can engage your students in one of three ways:

- Ask students to generate questions to quiz other students on the individual lesson concepts or on section concepts.
- Use one of the writing prompts provided in the Checking for Understanding section found at the end of each lesson to review other student's conceptual understanding.
- You might generate specific questions or writing prompts to assess students' knowledge of a specific concept in the lesson or section which you stressed.

Additional information on "PETRO Mail" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LEARNING JOURNALS

Using the writing prompts and questions found in the Checking for Understanding section, or using other prompts you have generated, have the students write continuously for 5 to 10 minutes.

Additional information on "Learning Journals" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LIVE-AT-FIVE INTERVIEWS

Have students interview an ecologist, using the following sample questions:

- What are the ways in which people dispose of used oil?
- Why are some of these disposal methods harmful to the ecosystem?
- Why is pollution in the hydrologic cycle so bad for the ecosystem?
- How does the Earth naturally dispose of toxic substances?
- Why is disposing of used oil in a landfill harmful to the surrounding environment?
- How does oil pollution affect a food chain and harm the entire food pyramid?
- What is the basis for the California Health and Safety Code law?

Additional information on "Live-at-Five Interviews" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CREATIVE EXPRESSION

To use this assessment activity, you can have students implement one of the following short-term or long-term projects:

Short-Term

- Create a diorama of a food chain, including all of the trophic levels.
- Create a diorama or poster of a working landfill and how oil disposal might leave the system.
- Create a diagram of the hydrologic cycle and how pollution effects the cycle.
- Create a video showing bioaccumulation in an ecosystem.
- Make a flipbook to trace a water molecule as it moves through the hydrologic cycle and encounters a type of pollution.

Long-Term

- Using the storyline script, continue the dialogue to explain the results of each investigation.
- Create a skit to illustrate one of the disposal methods of used oil and the problems of that disposal method.
- Make a video to explain the reasons for the California Health and Safety Code.
- Create a play or video to demonstrate the effects of biomagnification and bioaccumulation on the species in a food chain or web.

Additional information on "Creative Expression" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

GROUP EVALUATION POSTER SESSION OR WHITE BOARD

This activity can help you gauge students' preconceptions before each lesson begins, or during the Prethink portion of each lesson. Save the poster for review at the end of the lesson. If you do this activity on white boards, have the students record the ideas in their learning journals. You should refrain from adding information or correcting the students' statements. While students review their prior thinking during the Action Processing section of each lesson, you may want to ask questions to enable the students to dispel the misconceptions shown on the posters.

Sample prompts include:

- Explain how the modern landfill works and how disposal of used oil in the landfill may harm the surrounding environment.
- Explain how motor oil can enter into the hydrologic cycle and how this will affect organisms in the ecosystem.
- Explain why the California Health and Safety Code was written, using examples to illustrate your ideas.
- Explain the concept of biomagnification and bioaccumulation and how they affect organisms involved in a food chain or web.

Additional information on "Group Evaluation Poster Session or White Board" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

PORTFOLIOS

If you are using this assessment activity, students should take the following steps at this time:

- Make their third selections.
- Self-reflect as to why they chose the entry.
- Determine what they have learned about the chosen subject .
- Decide what they want to know.
- Present any questions they may still have, or generate any new questions.

Additional information on "Portfolios" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CONCEPT MAPS

To use this assessment activity, try one of the following ideas:

- Have students generate a list of high-frequency or key terms used in the day's activities or lessons, and then have them use this list to construct a concept map.
- Generate a list of key terms which you have determined to assess the students' conceptual understanding of the lesson, and then have students generate a concept map that includes these key terms.
- Use the following concept map to assess your students' conceptual understanding of the section. Provide your students with copies of *"Activity Page — Earth Resources Concept Map for Section 3."* Have your students fill in the blank concept map, using the list of key terms used. You may wish to fill in a few of the key terms to get students started. Use the corresponding Teacher Page to assess students' understanding.

Additional information on "Concept Maps" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

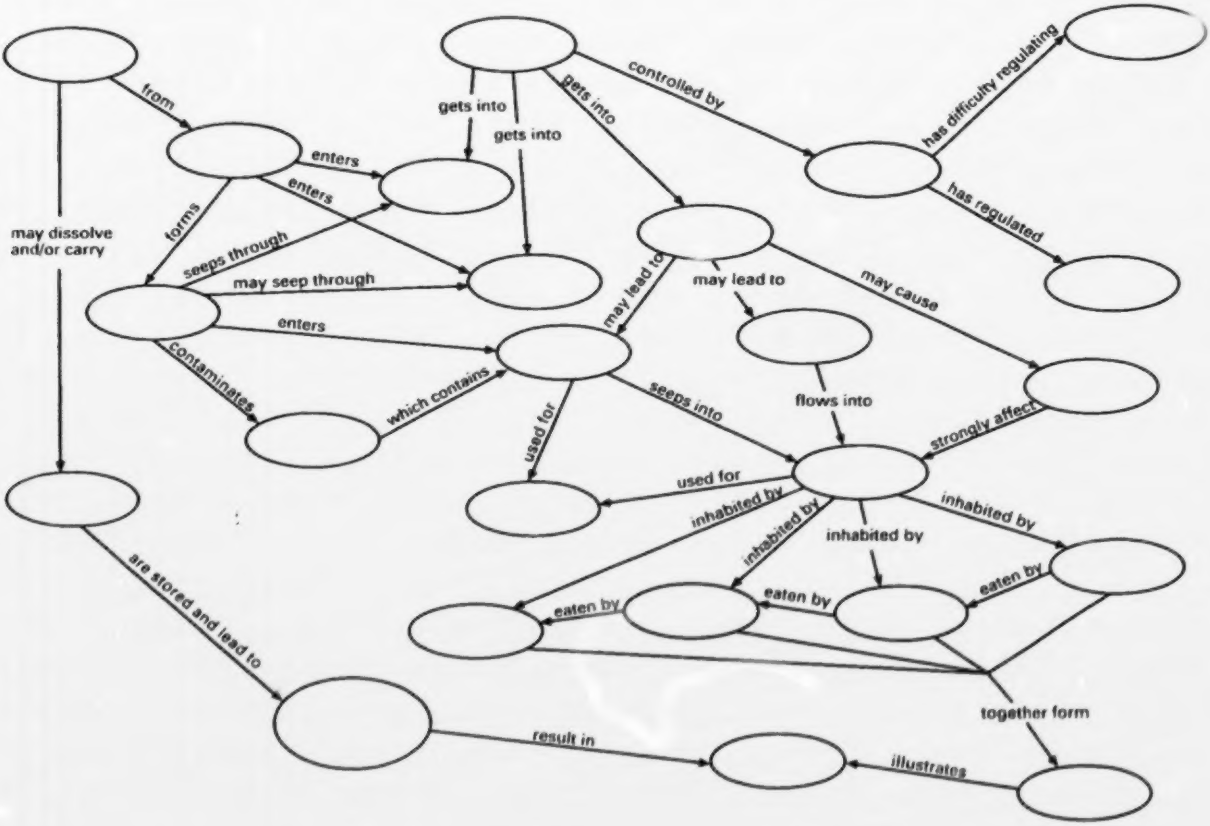
Name: ______________________ Date: __________

Earth Resources Concept Map for Section 3

Fill in the circles on the concept map using the key terms listed below. Each term shown on the list will be used once.

KEY TERMS

- aquifer
- bioaccumulation and bioconcentration
- biological magnification
- California law
- contaminants
- food pyramid
- groundwater
- lakes and rivers
- landfill
- leachate
- municipal water supplies
- non-point source pollution
- oil slicks
- point source pollution
- precipitation
- primary consumers
- producers
- runoff
- secondary consumers
- soil
- surface water
- tertiary consumers
- used oil
- water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may dissolve and/or carry
enters
enters
forms
gets into
gets into
gets into
controlled by
has difficulty regulating
has regulated
seeps through
may seep through
enters
contaminates
which contains
may lead to
may lead to
may cause
flows into
used for
seeps into
strongly affect
used for
inhabited by
inhabited by
inhabited by
inhabited by
eaten by
eaten by
eaten by
together form
are stored and lead to
result in
illustrates

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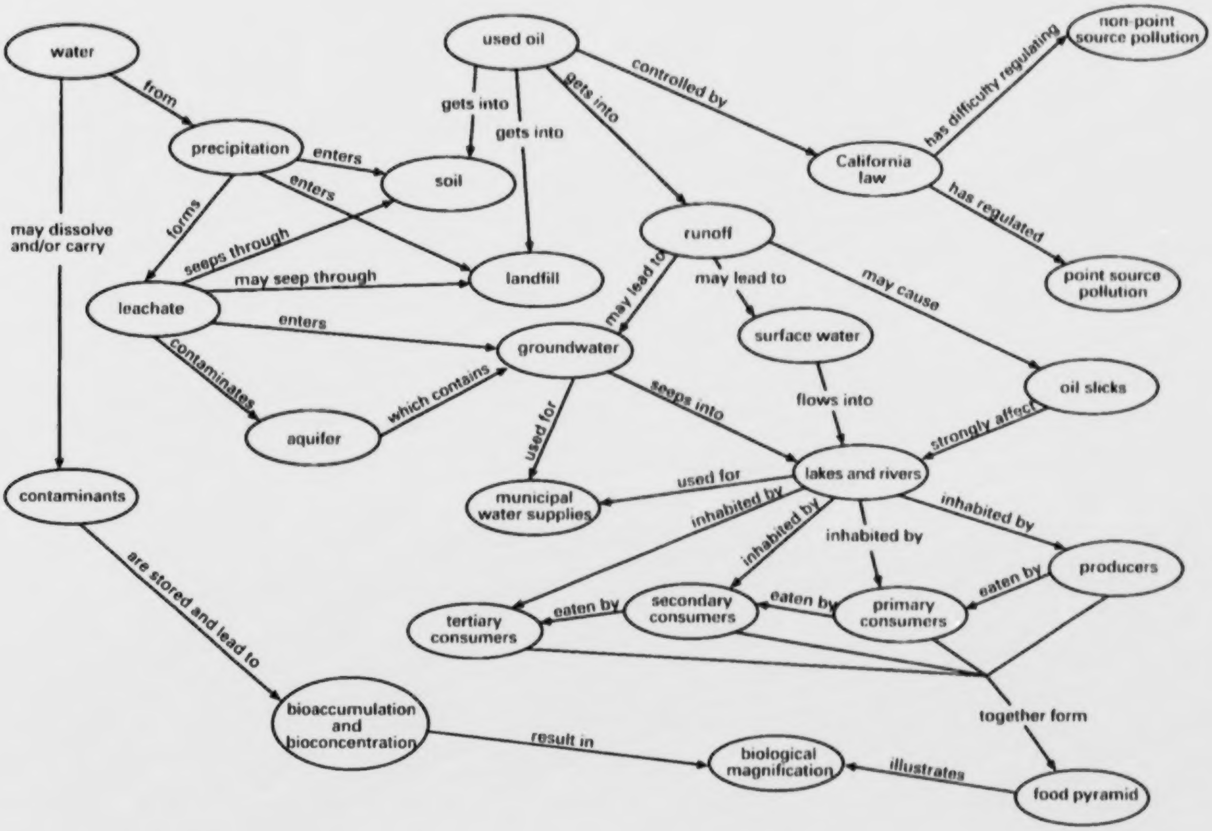
Earth Resources Concept Map for Section 3


water
from
precipitation
enters
soil
enters
forms
may dissolve and/or carry
used oil
gets into
gets into
gets into
controlled by
California law
has difficulty regulating
non-point source pollution
has regulated
point source pollution
runoff
may lead to
may lead to
may cause
landfill
seeps through
may seep through
leachate
enters
groundwater
surface water
flows into
oil slicks
strongly affect
contaminates
aquifer
which contains
used for
seeps into
lakes and rivers
used for
municipal water supplies
inhabited by
inhabited by
inhabited by
inhabited by
producers
eaten by
primary consumers
eaten by
secondary consumers
eaten by
tertiary consumers
together form
food pyramid
illustrates
biological magnification
result in
bioaccumulation and bioconcentration
are stored and lead to
contaminants

SECTION 3:

Earth Resources Project — Student Case Study

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interactions of matter and energy.

LESSON CONCEPT

All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.

SECTION 3:

Disposing of Our Earth's Resources

Section Concepts

Human: Materials from human societies affect both physical and chemical cycles of the Earth.

Scientific: Because ecosystems are interdependent, a change in one system may have far-reaching effects on the others.

LESSON OVERVIEW

Students have already selected an Earth resource, other than oil, on which to conduct research for their own case study. After completing Section 3, students spend another day researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

After Section 3, students research the following:

- Options for disposal of the resource after it is used
- Advantages and disadvantages of disposal options with regards to the environment, human quality of life, and economics

DESIRED OUTCOMES

Students will:

Identify questions and concepts about an Earth resource.

Design and *conduct research* on an Earth resource.

Formulate, *revise*, and *synthesize* the newly gained information.

Recognize and *analyze* alternate explanations and models about an Earth resource.

Continue creating a presentation about an Earth resource.

Students will use the following scientific thinking processes:

Observing, communicating, comparing, ordering, categorizing, relating, inferring, and applying.

STEPS FOR TEACHING

Teacher Action	Student Action	Suggested Time
Ask students to review the stages of the Earth Resources Chart.	*Examining Prior Ideas*	5 min.
Direct students to brainstorm what they know and want to know about their chosen resource.	*Inferring, Applying, and Relating Information*	5 min.
Guide students in the appropriate research methods and emphasis for their chosen resource.	*Relating Information*	5 min.
Provide time and resources for students to conduct research.	*Applying Knowledge*	50 min.

BACKGROUND FOR TEACHERS

The *National Science Education Standards* emphasize that students should experience science as inquiry which engages them in the active construction of ideas and explanations. Teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich the understanding of science.

Students should be guided to generate questions that make it possible "to analyze data, develop a richer knowledge base, reason using science concepts, make connections between evidence and explanations, and recognize alternative explanations. Ideas should be examined and discussed in class so that other students can benefit from the feedback." Teachers of science can use the ideas of students in their class, ideas from other classes, and ideas from texts, databases, or other sources.

Reference:
National Research Council, *National Science Education Standards*. National Academy Press, Washington, D.C., 1996.

GETTING READY

- ☐ Obtain materials (see *"What You Will Need")*.
- ☐ For each student, photocopy:
  - *"Activity Page — Earth Resources Project — Student Case Study"* (for Section 3)
- ☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).
- ☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.
- ☐ Take out the overhead transparencies, *"Earth Resources Chart"* and *"Earth Resources Chart — Section 3."*

TEACHER NOTES

In this lesson, students continue applying the pattern of the stages of resource use to another resource.

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

Gather as many reference materials as possible. Some possible resources include:

- *Energy Skill Builders* and *Energy 90s*, Enterprise for Education, 1316 Third St., Ste. 103, Santa Monica, CA 90401; (310) 394-9864
- *Guidebook for Federal Resources for K-12 Mathematics & Science*, Eisenhower National Clearinghouse, 1-800-621-5785, editor@enc.org
- *Ground Water Education for Secondary Students*, Water Education Foundation, 717 K St., Ste. 517, Sacramento, CA 95814; (916) 444-6240, <www.water-ed.org>

At the conclusion of each section of the curriculum, provide at least one class session for students to research in class. However, students should also work independently, revisiting their case study as the unit proceeds.

Students often have difficulty planning ahead and pacing their work. Therefore, it is a good idea to set up "checkpoint" dates by which students must complete various stages of research.

KEY WORDS

CASE STUDY
Collected information about an individual, group, or object for use in sociological, medical, environmental, scientific, or psychiatric studies.

SUSTAINABLE
Able to preserve the functioning of existing systems in such a way that resources are not depleted or permanently damaged.

ACTION NARRATIVE

Prethink
15 minutes

Let's review the Earth Resources Chart to determine what we have learned about oil thus far.

▶ Display one or both of the overhead transparencies, **"Earth Resources Chart" and/or "Earth Resources Chart — Section 3."**

Ask a student to review and explain each column of the chart, or do it yourself.

Consider the Earth resource you chose for your case study in Lesson 1. Brainstorm what you know and what you want to know about your Earth resource.
Ask a few students to share their brainstorms.

▶ Distribute *"Activity Page — Earth Resources Project – Student Case Study (Section 3)."*

Today, each of you will continue to research your questions about the Earth resource you have chosen, as well as the answers to questions on the Activity Page.
Discuss all elements of the Activity Page with students. Be sure to remind students that at the end of the entire unit they will use their research to develop a product that will be used as a vehicle to present their study. Review the types of end product that are acceptable to you. Remind students that their projects will be evaluated for quality of presentation and for adequate treatment of each of the stages in the Earth Resources Chart. If you decide to have students give an oral presentation, review the guidelines for oral presentations.

Student Action
45 minutes

Provide the resources and time necessary for students to begin researching information. Assist, guide, and facilitate as necessary.

Action Processing
5 minutes

Who will share one interesting or surprising fact or idea you learned today?
Allow a few students to share after each day of research.

Be sure to continue working outside of class and at home to complete your research on this section. See me if you need any help.
Remind students that they should be compiling information for their case study in preparation for their culminating report and presentation, which will take place in Lesson 18. Be sure to remind the students of the due date as well as the type of product you will be expecting.

Home Study
Students should continue their ongoing research during the next section. Periodically remind students of this and ask them to share a bit of what they have learned.

CHECKING FOR UNDERSTANDING

Student Reflections

- I discovered that...
- I was interested/surprised to learn that...

Teacher Reflections

Can students find the necessary information for each stage of the Earth Resources Chart?

- Do the students realize that each Earth resource follows the pattern of the Earth Resources Chart?

EXTENSION

Use this research opportunity to collaborate and integrate with the students' English class. The use of research tools such as source cards and note cards, outlines, and rough drafts is taught in English courses; their use can enhance this scientific case study.

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Name: ____________________ Date: ________

Earth Resources Project – Student Case Study (Section 3)

Continue to conduct research as you develop your own case study. Centering on the Earth resource you chose, focus on the types of disposal methods for the resource after it has been processed and used. Use the categories from the Section 3 portion of the Earth Resources Chart to focus your research. Consider the impacts of exploration, processing, and use on the Earth's environment; the scientific technologies needed; and the supply of, and demand for, the resource.

PREPARATION

What do you know about the disposal methods for the Earth resource that you chose?	What do you want to know about the disposal methods for the Earth resource that you chose?

Additional Research Questions

Disposal of the Earth Resource

- After use, what are the different methods of disposal of the resource?
- What are the advantages and disadvantages of the disposal methods for the environment and human quality of life?
- What are the possible economic impacts of the various methods of disposal of your resource?

Notes

Section at a Glance: Section 4

UNIFYING CONCEPT

The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interaction of matter and energy.

SECTION 4 OVERVIEW

The fourth section discusses the processes and issues surrounding the recycling of used oil and used oil filters.

SECTION 4:

Reducing, Reusing, and Recycling Our Earth's Resources

Section Concepts

Human: Human activities should aim at maintaining a sustainable system through careful management of the Earth's resources.

Scientific: All matter has observable chemical and physical properties which govern its interactions.

LESSON OVERVIEWS

Lesson 15

What Difference Can I Make? *Exploring Used Oil Collection Opportunities*

Students identify opportunities to recycle used oil and other household hazardous waste in their community, and discuss the issues involved in the operation of collection centers that accept used oil and filters from the public.

Lesson 16

Used Oil Learns the 3 Rs: *Recycling, Re-Refining, Reusing*

Students analyze the steps in the processing and re-refining of used oil, simulate the filtration and quality-control steps in the processing of used oil, and compare used oil recycling to the refining of crude oil.

Lesson 17

New Oil Versus Old Oil: *A Qualitative Analysis*

Students discover that re-refined oil can be safely substituted for virgin oil.

Earth Resources Project — Student Case Study

Students have already selected an Earth resource, other than oil, on which to conduct research for their own case study. As they near the end of Section 4, students spend another day researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

Lesson 18

Earth Resources Case Study: *Sharing Solutions*

Students complete the unit by sharing their Public Information Announcements and Earth Resources Projects and finishing the Earth Resources Chart for oil.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	**Lesson Concept**	**Scientific Thinking Processes**	**Desired Outcomes** *Students will…*
LESSON 15. **What Difference Can I Make?** *Exploring Used Oil Collection Opportunities*	Individuals can make choices that conserve natural resources. Each individual's actions can make a difference.	• Communicating • Comparing • Ordering • Categorizing • Inferring • Applying	*Research* and *communicate* collection opportunities for used oil and filters. Students will *investigate* opportunities for recycling used oil and filters in their own communities. *Analyze* the considerations a business must make in providing collection services. Students will *explain* the risks involved and the training necessary in accepting used oil and filters from the public.
LESSON 16. **Learns the 3 Rs:** *Recycling, Re-Refining, Reusing*	Human technological systems have the capacity to reuse waste.	• Observing • Communicating • Comparing • Categorizing • Inferring • Applying	*Infer* that mixtures can be separated using physical processes that depend on differences in the physical properties of the substances. Students will *describe* the sequence necessary in processing used oil for reuse and *show* that contaminants can be separated from simulated used oil through the process of filtration.
LESSON 17. **New Oil Versus Old Oil:** *A Qualitative Analysis*	Human technological systems have the capacity to reuse waste.	• Observing • Communicating • Comparing • Applying	*Compare* the physical properties of an Earth resource with its recycled alternative. Students will *compare* the physical properties of virgin and re-refined oil. *Explain* that recycled resources are valuable because in most cases they can be substituted for the original resource. Students will *create* a method to educate members of the public about the qualities of re-refined oil and how it can substitute for virgin oil. *Generalize* that the capacity of technology to solve problems influences environmental quality. Students will *evaluate* the environmental trade-offs of re-refining used oil.

LESSON CONCEPTS, SCIENTIFIC THINKING PROCESSES, AND DESIRED OUTCOMES

Lesson Number and Name	Lesson Concept	Scientific Thinking Processes	Desired Outcomes *Students will…*
Earth Resources Project — *Student Case Study (Research Day)*	All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.	• Observing • Communicating • Comparing • Ordering • Categorizing • Relating • Inferring • Applying	*Identify* questions and concepts about an Earth resource. *Design* and *conduct research* on an Earth resource. *Formulate*, *revise,* and *synthesize* the newly gained information. *Recognize* and *analyze* alternate explanations and models about an Earth resource. *Create* a presentation about an Earth resource.
LESSON 18. **Earth Resources Case Study:** *Sharing Solutions*	Natural systems have the capacity to reuse waste.	• Communicating • Comparing • Relating • Applying	*Explain* that the use and improper disposal of an Earth resource influences environmental quality and can be detrimental to humans. Students will *communicate* problems and solutions associated with using and properly handling used oil and filters.

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Getting Ready For Section 4

Lesson 15

What Difference Can I Make? *Exploring Used Oil Collection Opportunities*

WHAT YOU WILL NEED

For the class:

- Interview responses from Lesson 11's *"Home Study — How Easy Is It To Recycle Oil?"*
- Six or more large sheets of poster paper or chart paper
- A large map of your community
- Used oil recycling center symbols (see *"Getting Ready"*)
- Push pins or tacks

Getting Ready

☐ Post the community map.

☐ Make used oil recycling center symbols to pin onto the map by photocopying *"Activity Page — Used Oil Recycling Center Symbols"* and cutting the symbols apart.

☐ Post the six sheets of poster paper around the room and, on each one, write the title of one of the six types of collection programs researched by students in Lesson 11's Home Study.

Lesson 16

Used Oil Learns the 3 Rs: *Recycling, Re-Refining, Reusing*

WHAT YOU WILL NEED

For the class:

- 2 L contaminated water (to simulate used oil), consisting of:
  - 2 L tap water
  - 1/2 tablespoon table salt (NaCl)
  - 1/2 cup used coffee grounds
- 1 distillation apparatus (optional)
- 1 conductivity meter (optional)
- Rubber tubing (optional)
- Videotape, *Evergreen: Redefining Tomorrow by Re-Refining Today*

For each group of students:

- 1 100-mL graduated cylinder
- Ring stand and ring clamp
- 2 150-mL beakers
- Funnel, medium to large-sized
- Clay triangle
- Paper cup
- Paper clip
- 1 filter paper (Whatman #1, 11-cm diameter)
- 1 125-mL Erlenmeyer flask
- 15 g decolorizing charcoal
- 150-200 g clean sand, pre-moistened
- 150-200 g clean gravel, pre-moistened

Getting Ready

☐ Set up a water distillation apparatus, which you will demonstrate at the close of the activity (optional).

☐ Set up a conductivity apparatus to be used to test the student purified water samples (optional).

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Lesson 17

New Oil Versus Old Oil: *A Qualitative Analysis*

WHAT YOU WILL NEED

For the class:

- Various samples of aluminum (e.g., can, foil, pan)
- Various samples of glass (e.g., jar, window pane, crystal)
- Various samples of plastic (e.g., bag, fork, jar lid)
- Various samples of paper (e.g., stationery, lined note paper, paper stating that it is made of recycled materials)
- Various samples of styrofoam (e.g., packing materials, spheres)
- Stopwatch or clock with a second hand
- Videotape, *Defining Rerefining*

For each group of students:

- Small container of re-refined oil
- Small container of virgin oil, with the same SAE rating as the re-refined oil sample
- Small container of tap water
- Newton spring scale
- 2 syringes labeled "New Oil" and "Re-Refined Oil"
- 6 screw-cap test tubes or 6 18x100 test tubes with stoppers
- Test tube rack
- 6 BBs

Getting Ready

☐ For students to compare the viscosity of the virgin and re-refined oils, prepare a warm water bath and an ice bath.

☐ Obtain a TV/videotape player and queue video if necessary.

Earth Resources Project — Student Case Study (Research Day)

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

Getting Ready

☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).

☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.

Lesson 18

Earth Resources Case Study: *Sharing Solutions*

WHAT YOU WILL NEED

For each class:

- Students' Public Information Announcements
- Earth Resources Projects — Student Case Studies
- Videotape, *Fuel-Less* (optional)

Getting Ready

☐ Obtain TV/videotape player and queue video if necessary.

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Storyline

One way to attract students' attention to the issues surrounding the recycling of used oil and oil filters and get them involved in the curriculum is to use the following storyline. Choose three students to perform the following skit in front of the class. Provide time for them to learn their roles prior to the performance.

ANALYSIS OF A RESOURCE: PART 4

The Final Cleanup

Characters: Narrator, Cecylia, Mom

Narrator: Cecylia has completed her experiments and discovered that many people have the wrong ideas about used oil.

Cecylia: Mom, I have learned a lot from my simple experiments with the used oil from our motor. But it is scary that there are so many people who do not know the truth about the dangers of used motor oil if it is not taken to the recycling place and is put in the wrong place, instead. It can really cause problems for the environment.

Mom: You're right, Cecylia. Used motor oil can be handled in a very responsible manner. You know, we can call our local waste management agency to find out the best method of handling this used oil.

Cecylia: People also need to know that used oil should be recycled. I wonder how many people are aware of this?

Mom: I don't know, Cecylia. Maybe you could do some research around town and find out.

Cecylia: OK, Mom. But in the meantime I want to tell everyone in our neighborhood about used oil recycling. Do you think I could call the newspaper and they would interview me?

Mom (laughing): It is certainly worth a try! In the meantime, let's think of other ways in which we can educate the entire community about how important and easy it is to recycle used oil.

Suggested Strategies for Assessment

Section 4

PETRO MAIL

To use this assessment activity, you can engage your students in one of three ways:

- Ask students to generate questions to quiz other students on the individual lesson concepts or on section concepts.
- Use one of the writing prompts provided in the Checking for Understanding section found at the end of each lesson to review other students' conceptual understanding.
- Generate specific questions or writing prompts to assess students' knowledge of a specific concept in the lesson or section which you stressed.

Additional information on "PETRO Mail" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LEARNING JOURNALS

Using the writing prompts and questions found in the Checking for Understanding section, or using other prompts you have generated, have the students write continuously for 5 to 10 minutes.

Additional information on "Learning Journals" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

LIVE-AT-FIVE INTERVIEWS

To use this assessment activity, you can engage your students in one of two ways:

- Have your students interview an oil engineer, using the following sample questions:
    - What is the process for the recycling of used oil?
    - What are the uses for recycled oil?
    - Is recycled lubricating oil the same as new oil?
    - Some people don't recycle their oil. Why do you think they don't?
    - Are there places in our community where used oil can be taken?
    - How will recycling oil help conserve the natural resource?
- Have your students interview an average citizen, using the following sample questions:
    - Have you used recycled oil in your car? Why or why not?
    - Do you change your own oil?
    - When you change your oil, do you recycle it?
    - Do you know if there are recycling places in your area?
    - Do you think we will run out of crude oil someday? Explain.
    - What do you do to help to conserve the resources of the Earth?
    - Are you concerned about the effects of pollution on the environment? Why or why not?
    - What can you do to help sustain the resources of the Earth?

Additional information on "Live-at-Five Interviews" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CREATIVE EXPRESSION

To use this assessment activity, you can have students implement one of the following short-term or long-term projects:

Short-Term

- Create a bulletin board to illustrate the process of oil re-refinement
- Create a brochure to illustrate the steps in recycling an oil filter
- Create a short info-mercial to explain that there is no difference between reprocessed and new motor oil.
- Create a poem to help people understand why recycling is important to the sustainability of the Earth's natural resources.

Long-Term

- Create an info-mercial to demonstrate that there is no difference between new oil and re-processed oil. Be sure to explain the steps for re-processing.

- Using the beginning skit, continue the storyline to help people understand the reason for recycling.
- Create a video to explain why recycling oil is important today and in the future.
- Create a skit or video explaining that the power of one person's actions can make a difference in helping to sustain the resources of the Earth.

Additional information on "Creative Expression" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

GROUP EVALUATION POSTER SESSION OR WHITE BOARD

This activity can help you gauge students' preconceptions before each lesson begins, or during the Prethink portion of each lesson. Save the poster for review at the end of the lesson. If you do this activity on white boards, have the students record the ideas in their learning journals. You should refrain from adding information or correcting the students' statements. While students review their prior thinking during the Action Processing section of each lesson, you may want to ask questions to enable the students to dispel the misconceptions shown on the posters.

Sample prompts include:

- Explain the re-processing of used oil.
- Compare and contrast new and used motor oil.
- Explain how recycling oil aids in conserving and the sustaining the Earth's resources.
- With your table group, compare and contrast various aspects of the resources that you have researched; for example, the quantity of resource that is disposed of, the uses of the resource, the quantity of the resource that is (and has been) recycled, and the ways of recycling and re-processing the resource.
- Compare and contrast the methods of re-processing used oil with the methods of processing the resource that you have researched.
- Explain the notion that one person can make a difference.

Additional information on "Group Evaluation Poster Session or White Board" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

PORTFOLIOS

If you are using this assessment activity, students should take the following steps at this time:

- Make their final selections.
- Self-reflect as to why they chose the entry.
- Determine what they learned about the chosen subject.
- Present their final conclusions.

Additional information on "Portfolios" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

CONCEPT MAPS

To use this assessment activity, try one of the following ideas:

- Have students generate a list of high-frequency or key terms used in the day's activities or lessons, and then have them use this list to construct a concept map.
- Generate a list of key terms which you have determined to assess the students' conceptual understanding of the lesson, and then have students generate a concept map that includes these key terms.
- Use the following concept map to assess your students' conceptual understanding of the section. Provide your students with copies of *"Activity Page — Earth Resources Concept Map for Section 4."* Have your students fill in the blank concept map, using the list of key terms used. You may wish to fill in a few of the key terms to get students started. Use the corresponding Teacher Page to assess students' understanding.

Additional information on "Concept Maps" can be found in *"Assessment Strategies,"* located at the front of the curriculum.

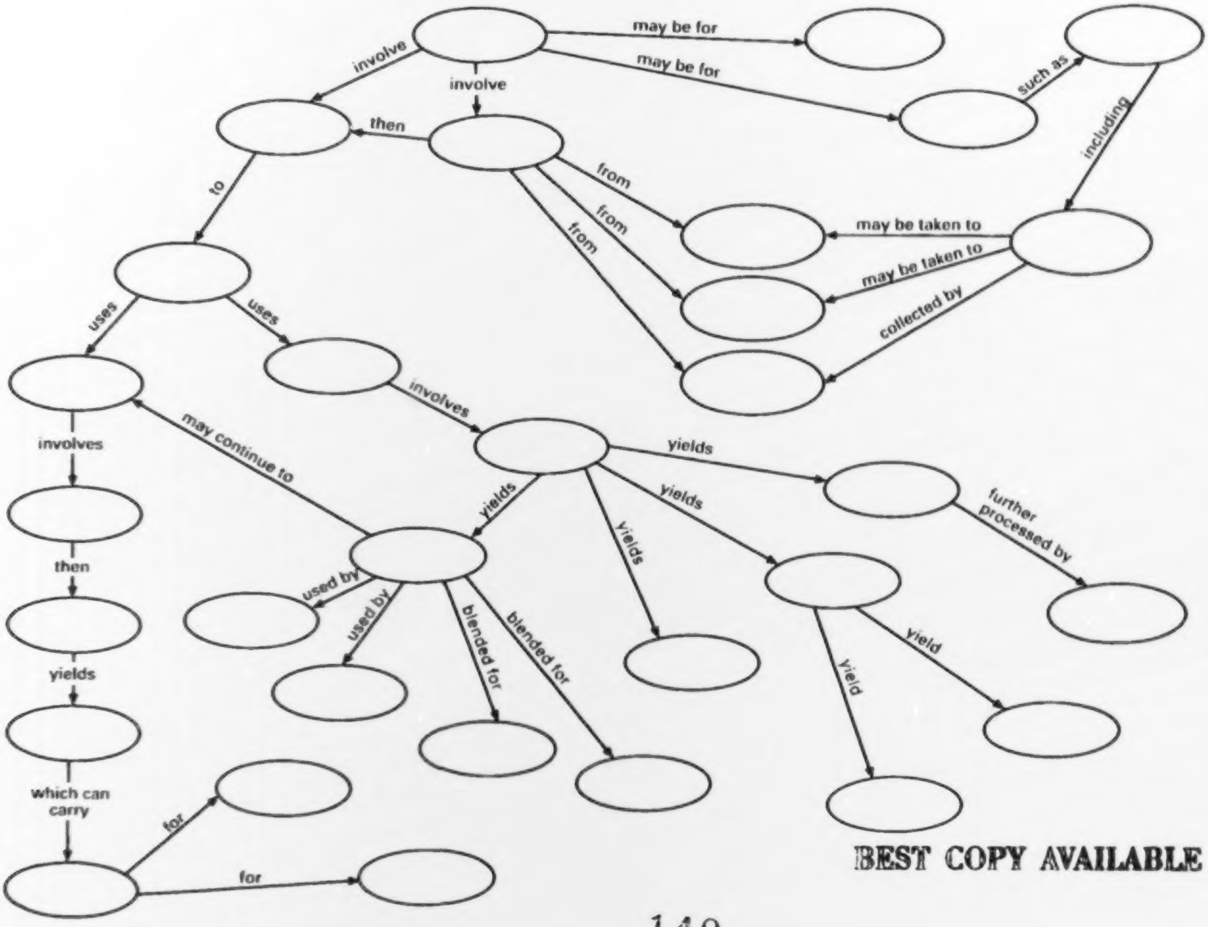
Name: ______________________ Date: __________

Earth Resources Concept Map for Section 4

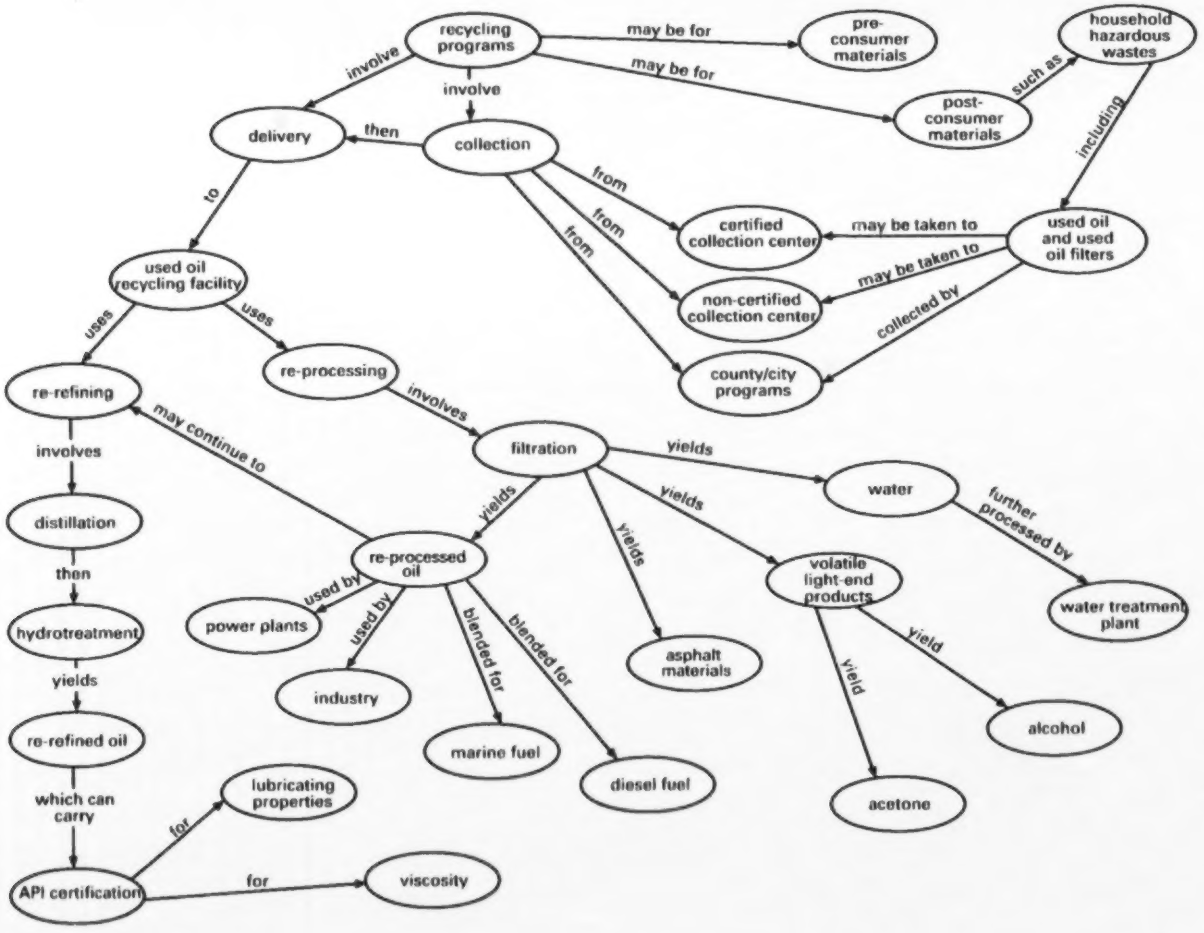
Fill in the circles on the concept map using the key terms listed below. Each term shown on the list will be used once.

KEY TERMS

- acetone
- alcohol
- API certification
- asphalt materials
- certified collection center
- collection
- county/city programs
- delivery
- diesel fuel
- distillation
- filtration
- household hazardous wastes
- hydrotreatment
- industry
- lubricating properties
- marine fuel
- non-certified collection center
- post-consumer materials
- power plants
- pre-consumer materials
- re-processed oil
- re-processing
- re-refined oil
- re-refining
- recycling programs
- used oil and used oil filters
- used oil recycling facility
- viscosity
- volatile light-end products
- water
- water treatment plant


may be for
may be for
involve
involve
such as
then
including
from
from
from
to
may be taken to
may be taken to
collected by
uses
uses
involves
involves
may continue to
yields
yields
yields
yields
further processed by
then
used by
used by
blended for
blended for
yield
yield
yields
which can carry
for
for

Earth Resources Concept Map for Section 4


recycling programs
may be for
pre-consumer materials
may be for
post-consumer materials
such as
household hazardous wastes
including
used oil and used oil filters
involve
involve
delivery
then
collection
from
from
from
certified collection center
may be taken to
non-certified collection center
may be taken to
county/city programs
collected by
to
used oil recycling facility
uses
uses
re-refining
re-processing
involves
filtration
may continue to
yields
water
further processed by
water treatment plant
yields
re-processed oil
yields
asphalt materials
yields
volatile light-end products
yield
acetone
yield
alcohol
used by
power plants
used by
industry
blended for
marine fuel
blended for
diesel fuel
involves
distillation
then
hydrotreatment
yields
re-refined oil
which can carry
API certification
for
lubricating properties
for
viscosity

SECTION 4:
Earth Resources Project — Student Case Study

UNIFYING CONCEPT
The Earth is a complex system that changes over time, yet exists in a dynamic balance that is affected by human populations. The balance is governed by the interactions of matter and energy.

LESSON CONCEPT
All of the Earth's materials, used by humans as resources, pass through a series of identifiable stages.

SECTION 4:
Reducing, Reusing, and Recycling Our Earth's Resources

Section Concepts

Human: Human activities should aim at maintaining a sustainable system through careful management of the Earth's resources.

Scientific: All matter has observable chemical and physical properties which govern its interactions.

LESSON OVERVIEW
Students have already selected an Earth resource, other than oil, on which to conduct research for their own case study. As they near the end of Section 4, students spend another day researching, tracing, synthesizing, and analyzing how the resource fits into the Earth Resources Chart.

During Section 4, students research the following:

- Possible future uses of the resource
- Method(s) of reducing, reusing, and/or recycling the resource
- Impact of the methods of reducing, reusing, and/or recycling the resource
- Actions they and others can take to make a difference in sustaining the resource

DESIRED OUTCOMES
Students will:

Identify questions and concepts about an Earth resource.

Design and *conduct research* on an Earth resource.

Formulate, revise, and *synthesize* the newly gained information.

Recognize and *analyze* alternate explanations and models about an Earth resource.

Create a presentation about an Earth resource.

Students will use the following scientific thinking processes:

Observing, communicating, comparing, ordering, categorizing, relating, inferring, and applying.

STEPS FOR TEACHING

Teacher Action	Student Action	Suggested Time
Ask students to review the stages of the Earth Resources Chart.	*Examining Prior Ideas*	5 min.
Direct students to brainstorm what they know and want to know about their chosen resource.	*Inferring, Applying, and Relating Information*	5 min.
Guide students in the appropriate research methods and emphasis for their chosen resource.	*Relating Information*	5 min.
Provide time and resources for students to finish conducting research and to finalize their presentations.	*Applying Knowledge*	50 min.

BACKGROUND FOR TEACHERS

The *National Science Education Standards* emphasize that students should experience science as inquiry which engages them in the active construction of ideas and explanations. Teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich the understanding of science.

Students should be guided to generate questions that make it possible "to analyze data, develop a richer knowledge base, reason using science concepts, make connections between evidence and explanations, and recognize alternative explanations. Ideas should be examined and discussed in class so that other students can benefit from the feedback." Teachers of science can use the ideas of students in their class, ideas from other classes, and ideas from texts, databases, or other sources.

Reference:
National Research Council, *National Science Education Standards*. National Academy Press, Washington, D.C., 1996.

GETTING READY

- ☐ Obtain materials (see *"What You Will Need")*.
- ☐ For each student, photocopy:
  - *"Activity Page — Earth Resources Project — Student Case Study"* (for Section 4)
- ☐ Arrange for the class to conduct research in the school library/media center for one or more class session(s).
- ☐ If necessary, ask the librarian/media specialist to set aside some reference materials for a reserve section.
- ☐ Take out the overhead transparencies, *"Earth Resources Chart"* and *"Earth Resources Chart — Section 4."*

KEY WORDS

CASE STUDY
Collected information about an individual, group, or object for use in sociological, medical, environmental, scientific, or psychiatric studies.

SUSTAINABLE
Able to preserve the functioning of existing systems in such a way that resources are not depleted or permanently damaged.

TEACHER NOTES

In this lesson, a final class session of research, students continue applying the stages of the Earth Resources Chart to their chosen resource. This lesson, or research day, should be scheduled at least a few days prior to Lesson 18. Following this final research day, be sure to allow time for students to finish developing their presentations (in or outside of class, at your discretion). Lesson 18 will provide students an opportunity to present their finished projects.

In assessing the project during Lesson 18, consider not only the quality of presentation, but whether each stage of the Earth Resources Chart was given adequate treatment.

WHAT YOU WILL NEED

For the class:

- Research materials, such as:
  - 4 to 5 different sets of encyclopedias, both print and electronic
  - Selection of pamphlets and books about the chosen materials and resources
  - List of local resource agencies
  - Internet access with specific bookmark addresses (if possible)

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ACTION NARRATIVE

Prethink

15 minutes

Let's review the Earth Resources Chart to determine what we have learned about oil thus far.

- ▶ Display one or both of the overhead transparencies, *"Earth Resources Chart"* and/or "Earth Resources Chart — Section 4."

Ask a student to review and explain each column of the chart, or do it yourself.

Consider the Earth resource you chose for your case study in Lesson 1. Brainstorm what you know and what you want to know about your Earth resource. Ask a few students to share their brainstorms.

- ▶ Distribute *"Activity Page — Earth Resources Project – Student Case Study (Section 4)."*

Today, each of you will continue to research your questions about the Earth resource you have chosen, as well as the answers to questions on the Activity Page. Discuss all elements of the Activity Page with students. Remind students that their projects will be evaluated for quality of presentation and for adequate treatment of each of the stages in the Earth Resources Chart. If you decide to have students give an oral presentation, review the guidelines for oral presentations.

Student Action

45 minutes

Provide the resources and time necessary for students to begin researching information. Assist, guide, and facilitate as necessary.

Action Processing

5 minutes

Who will share one interesting or surprising fact or idea you learned today? Allow a few students to share after each day of research.

Home Study

Be sure to continue working outside of class and at home to complete your research on this section. See me if you need any help.
Remind students that their presentations must be ready to present by the beginning of Lesson 18.

CHECKING FOR UNDERSTANDING

Student Reflections

- I discovered that...
- I was interested/surprised to learn that...

Teacher Reflections

- Can students find the necessary information for each stage of the Earth Resources Chart?
- Do the students realize that each Earth resource follows the pattern of the Earth Resources Chart?

EXTENSION

Use this research opportunity to collaborate and integrate with the students' English class. The use of research tools such as source cards and note cards, outlines, and rough drafts is taught in English courses; their use can enhance this scientific case study.

Name: Date:

Earth Resources Project – Student Case Study (Section 4)

Continue to conduct research to complete your own case study. Centering on the Earth resource you chose, focus on the future uses for the resource. Use the categories from the Section 4 portion of the Earth Resources Chart to focus your research. Consider the impacts of exploration, processing, and use on the Earth's environment; the scientific technologies needed; and the supply of, and demand for, the resource

PREPARATION

What do you know about the future uses and recycling/re-using opportunities for the Earth resource that you chose?	What do you want to know about the future uses and recycling/re-using opportunities for the Earth resource that you chose?

Additional Research Questions

Future Uses for the Earth Resource

- What are the possible continued uses for the Earth resource?
- What method(s) can and should be used to conserve the resource (e.g., reducing, reusing and/or recycling)?
- What are the impacts, both positive and negative, of various future uses for the resource?
- What actions can individuals take to make a difference toward conserving the resource?
- What actions can organizations, cities, and businesses take to make a difference toward conserving the resource?

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Appendix A

Exploring Career Avenues

When elementary-school children are asked to consider what they would like to be when they grow up, they often respond swiftly with naive conviction, and their answers are almost always limited to the careers which have captured their imagination through stories and in the limited realms of their young day-to-day lives.

High school students are, of course, more aware of the infinite variety of careers that the world has to offer and the type of work that these careers entail. Yet, they often feel intimidated by the thought of preparing for a career path and searching for a job related to their career aspirations.

The following set of activities and tools is designed to enable students to explore different career avenues related to *Earth Resources* — in particular, careers in the environmental sector and petroleum and automotive industries. The activities and tools are also intended to help students analyze their skills and aspirations, as well as corresponding educational requirements, as they relate to prospective career choices.

By engaging in these activities, students will:

- Investigate a career in the environmental sector, petroleum industry, and/or automotive industry, using *"Info Page — Career Possibilities"* and *"Info Page — Places to Start: Web Sites for Career Exploration."* (Note that these lists of careers, organizations, and web sites are provided as suggestions; they are not intended to be comprehensive.)
- Describe the work responsibilities of their career choice and the possibility of advancement in this career; research the educational requirements for the career and locate institutions of higher education which offer the best education in the corresponding field of study; and research the ecological impact of their career choice, through *"Activity Page — Researching a Career."*
- Complete a self-assessment to analyze their skills as they relate to some of the career requirements, using *"Activity Page — Personal Survey: A Career Path Exercise."*
- Write a letter requesting a career mentor and/or an informational interview using *"Info Page — Sample Inquiry Letter"* as a model.
- Intern or "job shadow," for at least one week, with a mentor in the career which they have chosen; keep a journal of their daily experiences; and, if possible, take some on-the-job photographs using *"Info Page — Job Shadowing Strategies."* (These journals and photographs can and should later be included in their student portfolios.)

Teacher Notes

The job-shadowing activity may require some advance preparation. To help students make connections with a career mentor, compile a sample list of local government agencies and nearby industries that do work in the environmental sector, petroleum industry, or automotive industry, and compile lists of related educational and training programs at local universities, colleges, and technical training schools. If you invited guest speakers to your class during any portion of this curriculum — such as geologists, engineers, waste management representatives, urban or environmental planners, oil company representatives, used oil recyclers, water treatment plant operators, or hazardous waste haulers — you may want to ask them whether they would be interested in serving as career mentors and/or if they have additional contacts.

It is a good idea to review your students' proposed dialogue and review the rules of good phone etiquette before they begin making phone calls in search of a career mentor. You might also want to review students' letters requesting a career mentor and/or informational interview, before they are mailed.

An excellent source of information on job shadowing, career exploration, and school-community partnership strategies is the comprehensive Internet site of the National School-to-Work Office at <http://www.stw.ed.gov/>. This site offers a wealth of resources on the school-to-career movement.

In addition, the School-to-Career Office of the California Department of Education (CDE) offers a publication that contains resources to help educators design and implement rigorous, high-quality work-based learning experiences for students of all ages. This publication, titled *Work-Based Learning Guide,* can be ordered for $12.50 (plus tax, shipping, and handling) from the CDE Publications Division, Sales Office, P.O. Box 271, Sacramento, CA 95812-0271; (916) 445-1260.

Name: ______________________ Date: __________

Researching a Career

Use *"Info Page – Career Possibilities"* and "Info Page – *Places to Start: Web Sites for Career Exploration"* as well as additional references in your library and on the Internet to help you research answers to the following questions.

1. What career are you researching?

2. Describe the work and responsibilities of this career.

3. What are the most interesting aspects of this career, in your opinion?

4. What are the possibilities for advancement and the average yearly wage in this career?

Researching a Career (Continued)

5. Summarize the educational requirements for this career.

6. Which technical schools, colleges, and/or universities offer the best education for this career?

7. Describe the impact this career has on the environment, and whether this impact is positive or negative.

8. List three things about this career that you would like to know more about.

Name: ______________________ Date: __________

Personal Survey: A Career Path Exercise

Use *"Info Page – Career Possibilities"* and "Info Page – *Places to Start: Web Sites for Career Exploration"* as well as additional references in your library and on the Internet to help you complete the following survey for three types of careers that interest you.

Type of career I would like to have	Skills required for this career	Skills I already have that would help me in this career	My areas of strength that would help me in this career	My areas of weakness that would need to be improved for this career	Ways to improve my areas of weakness	Organizations I can contact to get more information about this career

Career Possibilities:
Examples of Automotive Industry Careers

Auto Service Worker/Lube Technician

Performs various fluid changes and routine auto repairs.

Automotive Stock Clerk

Maintains an automotive parts storeroom, inventories parts. Maintains availability of stock and purchases stock.

Automotive Technician

At an entry level: performs various fluid changes and routine auto repairs. At a master level: supervises and participates in repair, overhaul, and maintenance of automobiles.

Fleet Acquisition Specialist

Works for government and industry fleet services, providing professional-level technical and administrative support that involves the design, acquisition and replacement of the fleet. Administers and develops vehicle-related budgets, specifications, and contracts.

Fleet Manager

Supervises the operation and maintenance of fleet vehicles for automotive dealerships, government and industry fleet services.

Independent Shop Owner

Is responsible for all aspects of the business, including the repair and maintenance of cars and management of the business.

Motorcycle Mechanic

Services and repairs motorcycles.

Sales/Service Manager or Shop Manager

Oversees day-to-day operations of the shop (for automotive dealerships, fleet services, auto repair shops, and quick-lube shops).

Smog Check Technician

Performs smog inspections using diagnostic equipment and makes appropriate repairs.

FOR MORE INFORMATION ON AUTOMOTIVE INDUSTRY CAREERS:

American Petroleum Institute
1220 L Street, NW
Washington, D.C. 20005
(202) 682-8000
<http://www.api.org/>

Automotive Repair Coalition of California
915 L St., Ste. 1000
Sacramento, CA 95814
(916) 444-9742
Conducts lobbying activities and holds seminars and workshops.

Automotive Service Councils of California
758 University Ave.
Sacramento, CA 95825
(916) 924-9054
Provides assistance to Automotive Service Shop Owners.

Automotive Technicians Association International
222 Meirill St., Ste. 101
Birmingham, MI 48009
(810) 644-6190
Nationwide organization for automotive service technicians. Promotes skill recognition and provides placement information.

Career-Vocational Education Division
California Department of Education
P.O. Box 944272
Sacramento, CA 94244-2720
(916) 657-2532

National Institute for Automotive Service Excellence
13505 Dulles Technology Dr.
Herndon, VA 22071
(703) 713-3800
Tests and certifies the competence of automotive service technicians. Publishes a bibliographic listing of training materials for upgrading technicians' skills in automotive repair.

Service Technicians Society
400 Commonwealth Dr.
Warrendale, PA 15096
1-800-787-9596
Provides opportunity to exchange information with other technicians and receive training.

Society of Automotive Engineers, Inc. (SAE)
400 Commonwealth Dr.
Warrendale, PA 15096
1-800-787-9596
A worldwide society of over 65,000 members from the engineering and scientific communities.

Adapted from Little Shop of Horrors: Education Resource Manual for High School Automotive Shops, City of Anaheim Public Utilities Department, Used Oil Recycling Program, 1996

Career Possibilities: Examples of Environmental Careers

Biological Technician

Works with biologists studying living organisms.

Biologist

Studies living organisms and their relationship to their environment. Many biological scientists conduct research to develop solutions to human health problems and to preserve and repair the natural environment. Aquatic biologists study plants and animals living in water. Marine biologists study salt-water organisms, and limnologists study fresh-water organisms. Botanists study plants and their environment. Ecologists study the relationship among organisms and between organisms and their environment and the effects of influences such as population size, pollutants, rainfall, temperature, and altitude.

Chemical Technician

Works with chemists and chemical engineers, developing and using chemicals and related products and equipment. Some chemical technicians collect and analyze samples of air and water to monitor pollution levels.

Chemical Engineer

Applies the principles of chemistry and engineering to solve problems involving the production or use of chemicals. Frequently specializes in a particular operation such as oxidation or polymerization, or in a particular area such as pollution control or the production of specific products.

Chemist

Searches for and puts to practical use new knowledge about chemicals. With regards to the environment, some chemists develop processes which save energy and reduce pollution, such as improved oil refining and petrochemical processing methods.

Civil Engineer

Some civil engineers design and construct transportation, water-supply, and/or pollution-control systems. Others design and construct large buildings and building complexes, and/or repair or replace existing roads, bridges, and other public structures.

Construction Craft Laborer

May operate, maintain, and read hazardous waste monitoring devices; perform material and atmospheric sampling; build, clean, or maintain facilities for hazardous material removal and decontamination; and package and/or transport hazardous materials.

Environmental Compliance Specialist (Environmental Health Inspector)

Works primarily for State and local governments to ensure that food, water, and air meet government standards. This includes overseeing the treatment and disposal of sewage, refuse, and garbage. May also visit pollution sources and test for pollutants by collecting air, water, or waste samples for analysis. Tries to determine the nature and cause of pollution and initiate action to stop it.

Environmental Technician

May perform laboratory and field tests to monitor environmental resources and determine the contaminants and sources of pollution. May collect samples for testing or be involved in abating, controlling, or remediating sources of environmental pollutants. May be responsible for waste management operations, control and management of hazardous materials inventory, or general activities involving regulatory compliance. This career places a growing emphasis on pollution prevention activities.

Geologist

Studies the physical aspects and history of the Earth. Identifies and examines rocks, studies information collected by remote sensing instruments in satellites, conducts geological surveys, constructs field maps, and uses instruments to measure the Earth's gravity and magnetic field. The geologist also analyzes information collected through seismic studies, which involves bouncing energy waves off buried rock layers. Many geologists and geophysicists search for oil, natural gas, minerals, and groundwater. Other geologists play an important role in preserving and cleaning up the environment. Their activities include designing and monitoring waste disposal sites, preserving water supplies, and reclaiming contaminated land and water to comply with federal environmental regulations. They also help locate safe sites for hazardous waste facilities and landfills. Geologists and geophysicists examine chemical and physical properties of specimens in laboratories. Some experiment with the flow of water and oil through rocks. Some use two- or three-dimensional computer modeling to portray water layers and the flow of water or other fluids through rock cracks and porous materials. Geologists who study marine geology are usually called oceanographers or marine geologists; they study and map the ocean floor, and collect information using remote sensing devices aboard surface ships or underwater research craft.

— Adapted from *1998-99 Occupational Outlook Handbook*, Bureau of Labor Statistics, U.S. Department of Labor, 1998

Hydrologist

Studies the distribution, circulation, and physical properties of underground and surface waters. Studies the form and intensity of precipitation, its rate of infiltration into the soil, movement through the Earth, and its return to the ocean and atmosphere. The hydrologist's work is closely related to geology and geophysics, and it is particularly important in environmental preservation and remediation.

Motor Vehicle Inspector

Verifies the compliance of automobiles and trucks with State requirements for safe operation and emissions. Inspects truck cargoes to assure compliance with legal limitations on gross weight and hazardous cargoes.

Urban Planner

Develops long- and short-term land use plans to provide for growth and revitalization of urban, suburban, and rural communities, while helping local officials make decisions concerning social, economic, and environmental problems. Addresses issues such the effect of growth and change on a community and on the environment. Some urban planners are involved in environmental issues ranging from pollution control to wetland preservation, forest conservation, or the location of new landfills. Often referred to as community, county, or city planners because most are employed by local governments.

Wastewater Treatment Plant Operator

Removes harmful pollutants from domestic and industrial wastewater so that it is safe to return to the environment. Controls the processes and equipment to remove solid materials, chemical compounds, and micro-organisms from wastewater or to render them harmless. Controls pumps, valves, and other processing equipment to move the wastewater through the various treatment processes, and disposes of the waste materials removed from the water.

Water Treatment Plant Operator

Treats water so that it is safe to drink. Controls the processes and equipment to remove solid materials, chemical compounds, and micro-organisms from water or to render them harmless. Controls pumps, valves, and other processing equipment to move the water through the various treatment processes, and disposes of the waste materials removed from the water.

FOR MORE INFORMATION ON ENVIRONMENTAL CAREERS:

American Chemical Society
Department of Career Services
1155 16th St., NW
Washington, D.C. 20036
Provides information on careers in chemistry and chemical engineering.

American Geological Institute
4220 King St.
Alexandria, VA 22302-1502
<http://www.agiweb.org>
Provides information on training and career opportunities for geologists.

American Geophysical Union
2000 Florida Ave., NW
Washington, D.C. 20009
Provides information on training and career opportunities for geophysicists.

American Institute of Biological Sciences
1444 I St., NW
Washington, D.C. 20005
<http://www.aibs.org>
Provides information on careers in the biological sciences.

American Institute of Chemical Engineers
345 East 47th St.
New York, NY 10017-2395

American Planning Association
Education Division
122 South Michigan Ave., Ste. 1600
Chicago, IL 60630-6107
Provides information on careers in urban and regional planning.

American Society of Civil Engineers
1801 Alexander Bell Dr.
Reston, VA 20191-4400

American Water Works Association
6666 West Quincy Ave.
Denver, CO 80235
Provides information on careers in water treatment.

Association of Hazardous Materials Professionals
3919 Westerly Place, Ste. 200
Newport Beach, CA 92660
1-800-582-9747
Provides a networking forum for those involved in the management and safety of hazardous materials.

California Air Resources Board
2020 L St.
P.O. Box 2815
Sacramento, CA 95814
(916) 445-5630 (Personnel Office)

California Conservation Corps
1530 Capitol Ave.
Sacramento, CA 95814
1-800-952-5627
Offers employment and education to young women and men, ages 18 to 23.

California Department of Conservation
801 K St.
Sacramento, CA 95814
(916) 322-7685 (Personnel Office)
<http://www.consrv.ca.gov>

Career Possibilities: Examples of Environmental Careers (Continued)

California Department of Fish and Game
1416 Ninth St., 12th Fl.
Sacramento, CA 95814
(916) 653-8120 (Personnel Office)

California Department of Toxic Substances Control
Office of Pollution Prevention & Technology Development
P.O. Box 806
Sacramento, CA 95812-0806
(916) 323-2679 (Personnel Office) or (916) 322-3670
<http://www.cwo.com-opptd\>

California Department of Water Resources
1416 Ninth St.
Sacramento, CA 95814
(916) 653-6192 (Public Information)

California Environmental Protection Agency
555 Capitol Mall, Ste. 235
Sacramento, CA 95814
1-800-808-8058 (Help Line)

Career-Vocational Education Division
California Department of Education
P.O. Box 944272
Sacramento, CA 94244-2720
(916) 657-2532

Commencement 2000
USDA Forest Service Pacific Southwest Region
630 Sansome St.
San Francisco, CA 94111
(415) 705-2604
A program that focuses on environmental career awareness and precareer training.

Environmental Careers Organization
286 Congress St.
Boston, MA 02210-1009

Geological Society of America
P.O. Box 9140
Boulder, CO 80301-9140
<http://www.geosociety.org>
Provides information on training and career opportunities for geologists.

Hazardous Waste Association of California
1010 F St., Ste. 300
Sacramento, CA 95814
(916) 447-7571
Represents hazardous waste haulers, generators, and disposal facilities, and monitors legislation.

Integrated Waste Management Board
8800 Cal Center Drive
Sacramento, CA 95826
(916) 255-2557 (Personnel Office)

Junior Engineering Technical Society
JETS-Guidance
1420 King St., Ste. 405
Alexandria, VA 22314-2794
<http://www.asee.org/jets>
General information on a variety of engineering disciplines can be obtained by sending a self-addressed business-size envelope affixed with 6 first-class stamps.

Laborers' International Union of North America
905 16th St., NW
Washington, DC 20006
Provides general information about the work of construction craft laborers.

Marine Technology Society
1828 L St., NW, Ste. 906
Washington, D.C. 20036
Provides a list of education and training programs in oceanography and related fields.

State Water Resources Control Board
901 P St.
P.O. Box 100
Sacramento, CA 95812-0100
(916) 657-1738 (Personnel Office)

Student Conservation Association
Northern California:
655 13th St., Ste. 301
Oakland, CA 94612
(510) 832-0804
Southern California:
2600 Hoover St.
Los Angeles, CA 90007
(213) 747-6798
Offers volunteer conservation programs in parks, forests, and refuges in the United States, Canada, and Mexico.

Water Environment Federation
601 Wythe St.
Alexandria, VA 22314
Provides information on careers in water treatment.

Career Possibilities: Examples of Petroleum Industry Careers

Chemical Engineer

Helps improve the technology and methods used for drilling, completing, and simulating wells. May develop new product formulations or processing techniques, or may work on a team to test and develop promising new catalysts, or may use computer-controlled pilot plants to evaluate the scale-up of laboratory-sized reactions. May serve as a sales representative, helping to solve customers' technical problems.

Chemist

Searches for and puts to practical use new knowledge about chemicals. With regards to the environment, some chemists develop processes which save energy and reduce pollution, such as improved oil refining and petrochemical processing methods.

Civil Engineer

Civil engineers who work in the petroleum industry develop equipment and methods to support oil drilling, production, and manufacturing. They may improve design and analysis methods used on offshore structures and in offshore operations.

Drilling Engineer

Works on the technical and operational aspects of producing oil from new and existing wells.

Electrical Engineer

Conducts research on new designs for electric motors, motor starters, switch gear, power cables, program controllers, and advanced control systems.

Facilities Engineer

Takes charge of planning construction projects such as renovating a service station, extending a pipeline, or building a new plant from the ground up.

Geologist

Studies the physical aspects and history of the Earth. Identifies and examines rocks, studies information collected by remote sensing instruments in satellites, conducts geological surveys, constructs field maps, and uses instruments to measure the Earth's gravity and magnetic field. The geologist also analyzes information collected through seismic studies, which involves bouncing energy waves off buried rock layers. Many geologists and geophysicists search for oil and natural gas. Petroleum geologists explore for oil and gas deposits by studying and mapping the subsurface of the ocean or land. They use sophisticated geophysical instrumentation, well log data, and computers to collect information. They may experiment with the flow of water and oil through rocks. Some use two- or three-dimensional computer modeling to portray water layers and the flow of water or other fluids through rock cracks and porous materials.

Health and Safety Engineer

Focuses on day-to-day and long-term health and safety needs.

Mechanical Engineer

Helps improve the technology and methods used for drilling, completing, and simulating wells. May work on product enhancements for fuels and lubricants. May improve design and analysis methods used on offshore structures and in offshore operations.

Petroleum Engineer (includes Drilling Engineer, Reservoir Engineer, and Production Engineer)

Working with a team, helps to determine where and how an oil company should extract oil and gas. Helps improve the technology and methods used for drilling, completing, and simulating wells.

Petroleum Technician

Measures and records physical and geologic conditions in oil or gas wells using instruments lowered into wells or by analysis of the mud from wells. Collects and examines geological data or tests geological samples to determine petroleum and mineral content. Some petroleum technicians, called scouts, collect information about oil and gas well drilling operations, geological and geophysical prospecting, and land or lease contracts.

Planner/Economist

Works in a team to decide which tract of oil-producing land to purchase and drill on. Computes the financial success of major drilling operations.

Process Engineer

May monitor product yields, catalyst life and process efficiencies, and make recommendations that could increase plant efficiency or yield. May take part in defining needs for inspection, cleaning, and repair of equipment during plant shutdowns. May contribute ideas for redesigned processes to improve product quality, to reduce operating costs, or to

Adapted from Chevron Professional Opportunities and 1998-99 Occupational Outlook Handbook, Bureau of Labor Statistics, U.S. Department of Labor, 1998

Career Possibilities: Examples of Petroleum Industry Careers (Continued)

improve safety or the environment. May evaluate the potential economic or environmental advantages of a new research breakthrough, design a distillation column or reactor, or observe how a refinery or chemical plant performs in actual operation.

Production Engineer

Monitors the performance of producing fields and recommends and executes programs to improve production and profitability.

Reservoir Engineer

Works with geologists to conduct tests and develop reservoir performance simulations to prepare plans for developing oil and gas fields. Estimates the amount of oil and gas in a reservoir and evaluates the economics of extracting it with primary, secondary, or enhanced oil recovery techniques. Uses advanced computer simulation technology to understand the reservoir and performs economic analyses on a variety of projects such as water flooding, carbon dioxide flooding, steam drives, and offshore development.

For More Information on Petroleum Industry Careers:

American Association of Petroleum Geologists
Communications Dept.
P.O. Box 979
Tulsa, OK 74101

American Chemical Society
Department of Career Services
1155 16th St., NW
Washington, D.C. 20036
Provides information on careers in chemistry and chemical engineering.

American Institute of Chemical Engineers
345 East 47th St.
New York, NY 10017-2395

American Petroleum Institute
1220 L Street, NW
Washington, D.C. 20005
(202) 682-8000
<http://www.api.org/>

American Society of Civil Engineers
1801 Alexander Bell Dr.
Reston, VA 20191-4400

American Society of Mechanical Engineers
345 E. 47th St.
New York, NY 10017

California Department of Conservation, Division of Oil and Gas
801 K St.
Sacramento, CA 95814
(916) 322-7685 (Personnel Office)
<http://www.consrv.ca.gov>

Chevron, U.S.A.
<http://www.chevron.com/about/hr/index.html>

Independent Lubricant Manufacturers Association
651 S. Washington Street
Alexandria, VA 22314
(703) 684-5574
<http://www.ilma.org>

Institute of Electrical and Electronics Engineers
1828 L St., NW, Ste. 1202
Washington, D.C. 20036

Institute of Industrial Engineers, Inc.
25 Technology Park/Atlanta
Norcross, GA 30092
<http://www.iienet.org>

International Association of Drilling Contractors
<http://www.iadc.org>

National Oil Recyclers Association
12429 Cedar Road
Suite 26
Cleveland, OH 44106-3172
(216) 791-7316
<http://www.noroil.com>

Society of Petroleum Engineers
P.O. Box 833836
Richardson, TX 75083-3836
1-800-456-6863
<http://www.spe.org>

Places to Start: Web Sites for Career Exploration

Career and Educational Guidance Library: Career Exploration Links

A web site of the University of California, Berkeley
<http://www.uhs.berkeley.edu/CareerLibrary/links/careerme.htm>

Career Planning Center for Beginning Scientists and Engineers

A collaborative web site of the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council
<http://www2.nas.edu/cpc/index.html>

Catapult Career Choices

A web site of the National Association of Colleges and Employers
<http://www.jobweb.org/catapult/choice.htm>

Comprehensive Career Summaries from the 1998-99 Occupational Outlook Handbook

A web site of the U.S. Department of Labor, Bureau of Labor Statistics
<http://stats.bls.gov/ocohome.htm>

Environmental Careers Organization

A web site of the Environmental Careers Organization
<http://www.eco.org/>

Enviroworld

A web site of Environment 21 Magazine
<http://www.enviroworld.com>

Exploring Occupations: Getting You Started on Your Career Path

A web site of the University of Manitoba
<http://www.umanitoba.ca/counselling/careers.html>

Career and Job Info for Students

A web site of Federal Resources for Educational Excellence
<http://www.ed.gov/free/>

Job Opportunities with Chevron

A web site Chevron Corporation
<http://www.chevron.com/about/hr/index.html>

nternet Connections: Job Searching Resources

A web site of The Wallace Library, Rochester Institute of Technology
<http://wally.rit.edu/internet/jobs.html>

Job Opportunities with Shell

A web site of Shell Services Company
<http://www.shellus.com/jobs/joboppor.html>

Job Search FAQ's

A web site of the Career Relocation Corporation of America
<http://americasemployers.com/Faq/>

Job Searching and Career Exploration by Major Field of Study

A web site of the Montana State University-Bozeman
<http://www.montana.edu/wwwcp/academic.html>

Job Trak

A web site of the Jobtrak Corporation
<http://www.jobtrak.com>

Jobweb

A web site of the National Association of Colleges and Employers
<http://www.jobweb.com>

JETS: Engineering Careers

A web site of the Junior Engineering Technical Society
<http://www.asee.org/jets>

Kaplan Careers

A web site of Kaplan Educational Centers
<http://www1.kaplan.com/view/zine/0,1282,8,00.html>

Nation Job Online Jobs Database

A web site of the Nation Job Network
<http://www.nationjob.com>

Preparing for the Job Search

A web site of Oberlin College
<http://cs.oberlin.edu/students/csmc/jobs/>

Princeton Review Online Career

A web site of the Princeton Review
<http://www.review.com/career/>

Science's Next Wave: Resources for the Next Generation of Scientists
A web site of the American Association for the Advancement of Science
<http://www.nextwave.org/>

Student Center "About Work"

A web site of TMP Worldwide
<http://www.aboutwork.com/indexsc.html>

Job Shadowing Strategies

To job shadow is to follow an employer or employee at an agency or business to learn about a particular job or industry. Through job shadowing, you can observe a workplace, interview employees about their day-to-day responsibilities and their educational background, and record your observations of typical tasks and skills needed to perform those tasks.

Your job-shadowing experience should last at least one week. During this time, keep a journal in which you note your observations about the job. If possible, take photographs to illustrate various responsibilities of the job you are shadowing.

After selecting the type of job that you would like to shadow, your first step in preparing for a job shadowing experience is to answer the following questions:

- What do you want to learn from this experience?
- Why would you want to learn this?
- What do you feel is the purpose of this experience?

After you have answered these questions, the next step is to find a career mentor, an experienced employee or employer who will provide guidance as you learn about the job that you would like to shadow.

Possible Contacts:

To find your career mentor, talk to local universities, colleges, and technical training schools. In addition, contact U.S., State, and local government agencies (such as the Department of Forestry, Fire Department, Department of Agriculture, Department of Fish and Game, Department of Water Reclamation, Cal Trans, public utilities such as water treatment and waste management, and so on) which may have careers similar to those you are interested in. Such agencies often have internship programs. In addition, don't forget to contact private industries; they often welcome those interested in their profession as apprentices, job shadowers, or interns. If these agencies or industries can't provide you with a career mentor, ask them for other possible contacts.

If you have to make several phone calls, don't get discouraged – your politeness, patience, persistence will eventually lead you to the right person who can help.

What to Say:

After completing "Activity Page – Researching a Career," "Activity Page – Personal Survey: A Career Path Exercise," and the questions listed above, practice what you will say over the telephone. Be sure to get your teacher's approval on your proposed dialogue before you begin making phone calls.

Example:

Hello, my name is (name) from (school name). I am interested in becoming a (career choice). May I speak to whomever is the director of (name of related department) about the possibility of working with a mentor and learning more about (chosen career)?

When speaking to the director of an organization, make sure you introduce yourself once again and explain to him/her what you wish to learn. Be polite but persistent. Ask him/her to suggest a career mentor whom you could "job shadow" for at least one week. Mention that you became interested in this particular line of work while studying the importance of recycling used oil in your science class.

If you do not have success with this particular manager, don't give up! Ask this person to suggest other departments or companies to contact.

Writing an Inquiry Letter:

In today's workplace, communication skills are highly valued. Your correspondence with potential employers gives you the opportunity to illustrate your competence in writing clearly, concisely, and effectively.

After you obtain the name and address of one or more directors or managers of organizations where you would like to have a career mentor, write a letter to each person to inquire about the possibility of job shadowing. Use "Info Page – Sample Inquiry Letter" as an example. Even if you have already talked to possible contacts over the telephone, a letter can serve as a follow-up to confirm your interest in this opportunity.

Whether you are writing your letter to request a job shadowing experience, or to request an informational interview, be sure that you include the following:

- In the first paragraph, introduce yourself briefly and state the reason of the letter.
- In the second paragraph, tell why you are interested in the position or in working with a career mentor.
- In the final paragraph, propose some action on your part and anticipate a positive response. Indicate that you will make a phone call and that you would like to set up an interview. Remember to include your phone number. The number may be listed in this final paragraph or placed under your typewritten name.

Job-Shadow Interview:

After you find a career mentor, schedule a date to go in for an introductory interview. Be sure to dress for success; first impressions are important.

Job Shadowing Strategies (Continued)

During this introduction, be sure to ask the following questions:

- What will I be doing?
- What dress or appearance are considered appropriate?
- What days and times will I be shadowing?
- Whom will I be working with and whom will I be able to meet?
- Do I need to bring a lunch, or money for lunch?
- What safety precautions do I need to follow?
- Are there any other procedures, policies, or information that I need to be aware of before starting my job-shadowing experience?

Keep a Job-Shadowing Journal:

To help you get the most out of your job-shadowing experience, keep a job-shadowing journal.

- Make an entry in your log every day, recording what you did, what you learned, what you found interesting, and what you found difficult.
- Make sure to have your mentor sign your journal each day.
- At the end of your job-shadowing experience, ask your mentor to briefly remark on your learning experience on the page following your last entry in your journal.
- Be sure to take some photographs of yourself and your mentor on the job. These photos should be added to your portfolio.

Sample Inquiry Letter

234 Central Avenue
Sacramento, CA 95814
January 1, 1998

Ms. Jane Martinez
Employment Manager
Sacramento Municipal Water Treatment Plant
1818 Gilbreth, Suite 142
Sacramento, CA 95814

Dear Ms. Martinez:

As a student at Washington High School who is studying the effects of used oil disposal on water supplies, I am interested in exploring a career as a water treatment plant operator. Accordingly, I am requesting an opportunity to work with, or "job shadow," an employee of your organization who would be willing to be a career mentor on a part-time, after-school basis during a one-week period or longer.

Participating in a job shadowing experience will help me to learn firsthand about the job responsibilities and requirements of a water treatment plant operator. Such an experience will help me decide whether this is the type of work I would like to do someday. It will also help me to understand the steps I need to take to begin preparing for this career.

I would very much like to speak with you further about the possibility of participating in a job shadowing opportunity at your agency. I will contact you within the next week, hoping to arrange an introductory interview. If you have any questions, I can be reached by telephone at (916) 123-4567. Thank you very much for your time and assistance.

Sincerely,

James Mason, Jr.

Notes:

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Organization/Address:

CA Integrated Waste Management Board
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P.O. Box 4025
Sacramento, CA 95812-4025
www.ciwmb.ca.gov/Schools

Telephone: 916 341 6768

FAX: 916 319 7494

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